JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXL. AUGUST, 1895. No. 2

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THE PNEUMATIC FIRE-ALARM TELEGRAPH SYSTEM.

[*Being the report of the Franklin Institute through its Committee on Science and the Arts, on the invention of Albert Goldstein.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1895.

The Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating Goldstein's Fire-Alarm Telegraph System, reports as follows:

This device is entirely pneumatic and mechanical within the building protected, and embodies a magneto-electric machine for the transmission of the telegraphic alarm to the fire-department headquarters, and which is covered by the following patents:

Nos. 213,536; 242,803; 253,133; 446,863; 455,038; 479,909; dated respectively, March 25, 1879; June 14, 1881; January 31, 1882; February 24, 1891; June 30, 1891; July 26, 1892.

The system consists essentially of three parts, viz.: A thermostat, which acts under the influence of the heat of a fire near it; an annunciator, which receives the alarm from the detector or thermostat, and indicates it by visual room or floor signal and the ringing of a mechanical bell; and a transmitter, which is also actuated by the thermostat, and transmits the alarm by wire to a predetermined station; all these connected by closed pipes within the building.

The thermostat consists of a cylinder in which is a washer of asbestos coated with paraffine, and beneath the washer a loose-fitting piston, which receives the pressure of a spiral steel spring (piano wire), which spring is held under compression by a rod, the lower end of which is retained by two halves of a disk, which are held together by a solder which melts at a temperature of 150°.

When the thermostat is subjected to this temperature, the two halves of this disk part, releasing the rod and the spring, which, by its upward thrust on the piston and washer, with a quick impulse, drives the air in the cylinder through the pipe, producing a corresponding impulse upon a small bellows or diaphragm in the receiver. There may be many of these thermostats on the same floor pipe, and the pressure of an alarm is prevented from being expended in them by check valves, which yield to pressure from within but resist it from without the cylinders. The washer, saturated with paraffine, and fitting tightly in the cylinder, is hermetically sealed to it by the paraffine being melted around its edges, and is absolutely air-tight in its upward motion, in which it is facilitated by the softening of the paraffine from the heat to which the cylinder is subjected externally.

The pipes from each room or floor respectively, carrying a sufficient number of thermostats, are grouped together where they reach the annunciator, and the latter is connected by one pipe to the transmitter.

The annunciator contains a clockwork, adapted when released to ring a mechanical gong; a number of shutters, adapted when dropped to designate rooms or floors in the building; and a number of bellows connected to the respective pipes, adapted when actuated by an impulse of air from

a detector to drop the proper shutter and release the clock-work, thus ringing the local alarm and visually indicating the location of the fire. This local alarm runs for nearly fifteen minutes, and is for the purpose of alarming the occupants if present, and also for calling attention of the firemen, when they respond, to the annunciator, which indicates the particular location of the fire. For that purpose it is located preferably just within the main entrance of the building.

The transmitter consists essentially of a magneto-electric machine, impelled by a weight, which is released by an impulse of air from any thermostat in the building, and is electrically connected by wire with the central exchange of the local telephone company.

A wheel geared to the armature of this machine is furnished with contact springs, by which the number of the machine is telegraphically indicated in the usual way.

Thus, when any thermostat in a building protected by this apparatus is raised to a temperature of 150°, the fusible solder is melted, its spring is released, and its paraffined washer is driven up, sending an impulse of air to the annunciator and transmitter simultaneously; the former rings a bell, showing that there is a fire in the building, and drops a shutter showing the room or floor in which the fire exists. The shutter remains dropped until the firemen come, and at the same time the transmitter sends an alarm to the fire department headquarters, calling out the fire department and telegraphically indicating the building.

The transmitter is connected preferably to the existing telephone wire in the same building, or if there be none, to one adjacent to it; because these wires, being in constant use, are less liable to be out of order than those used for fire-alarm purposes only, and comparatively rarely tested. It is furnished with a device by which, when it is set in action from the operation of a detector, it automatically cuts out the telephone connection in the building and makes connection for itself, sending its alarm to the telephone exchange. These alarms are readily distinguishable by the telephone operator at the exchange, not only because of their marked

difference in tone from that of the ordinary magneto calls, but also because the telegraphic fire alarm number of the transmitter is audibly communicated fifteen times successively, in regular periodic impulses, impossible to misunderstand.

Upon the operator distinguishing the first one or two successive signals, or, in fact, merely recognizing their character, he plugs the line into the telephone line of the fire department, without moving from his seat in front of the switchboard, thereby making the special building conductor continuous all the way to the fire department. In that manner the alarms are transmitted direct to the fire department, notwithstanding that either of the two lines may have been in use when the automatic alarms started to come into the exchange. The transmitter communicates its fifteen successive signals in a period of two minutes, and at the end of that or any predetermined period, it automatically cuts out its own connection at the building, thereby restoring the telephone instrument to its normal connection with the line.

The alarms are distinguished at the telegraph bureau of the fire department by being printed upon a self-starting register, which records the impulses of current corresponding with the assigned fire alarm numbers of the transmitters in the usual way.

In cities where there are no telegraph operators employed at the fire department headquarters and where automatic repeaters are used in substitution, the alarms are caused to work directly through such automatic repeaters by extending any one of the city's fire-alarm circuits into the local telephone exchange and connecting a special type of relay direct to such city fire-alarm circuit, and upon receipt of alarms by the telephone operator, the latter can shunt the same into the city circuit by merely moving a switch connecting the subscriber's line with such special relay. If necessary, even this simple operation on the part of the telephone operator may be dispensed with, by providing automatic switches in place of manual switches, the former energized by electro-magnets wound to correspond with

the fire-alarm transmitters in the building, as, for example, a direct current instead of an alternating current, so as to be unaffected by impulses of alternating current from the use of the common type of magneto call movements used by telephone subscribers for the purpose of ringing up the exchange.

In relation to the state of the art in general, the system above described presents the following material advantages.

(1) It avoids the use of electric batteries in the various buildings and the constant attention they require to sustain them, and substitutes purely mechanical power that becomes operative only from the heat of a fire.

(2) It avoids the use of electric wires within the buildings and their attendant breakage and displacement, and substitutes iron pipe conductors, the same being as durable and permanent as the ordinary gas piping of a building.

(3) It avoids the use of the common type of electro-contact thermostats, which are variable and erratic under practical conditions, as they depend upon minute adjustments that appear to be impossible to be maintained with reliability and uniformity, and substitutes purely mechanical thermostats, rendered operative by the melting of fusible solder.

With regard to the transmission of the telegraphic alarms from the buildings to the fire department, the use of magneto-electric machines and existing telephone conductors presents the following advantages:

(1) It avoids the maintenance of the necessary closed-circuit and open-circuit batteries at a central station and the equipment of recording and repeating instruments at such point.

(2) It avoids the use of private metallic circuits, where two coincident line troubles cut off communication from all buildings located between such two foreign line troubles.

(3) It avoids the constant liability of signals interfering with each other by coming in together on the same circuit, and thereby conflicting and being rendered unintelligible.

(4) It avoids the use of overhead wires and their main-

tenance contrary to the regulations of the city authorities, and in many instances against the wishes or even without the knowledge of the owners of the buildings to which these wires are attached.

On the whole, the system in brief presents the following affirmative advantages:

(1) A purely mechanical local power.
(2) A purely mechanical thermostat.
(3) Iron pipe conductors.
(4) A purely mechanical annunciator.
(5) A purely mechanical electro-transmitter.
(6) An independent (underground) circuit, for each building, constantly used, and for that reason constantly tested.
(7) Either a slight manual operation at the exchange to make the signal go direct to the fire department, without the delay of re-transmission, or automatic switches in place of any operation whatever by operators.

The system in question, both in its broad conception and mechanical execution of details, evidences a marked intelligence and discrimination, in consideration of which, and of the beneficial results demonstrated by many practical tests, the Institute recommends the award of the John Scott Legacy Premium and Medal to Albert Goldstein, for his pneumatic fire-alarm telegraph system.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, February 6, 1895.

JOS. M. WILSON, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by

SAMUEL SARTAIN, *Chairman.*

Award confirmed by the Board of Directors of City Trusts, June 10, 1895.

APPENDIX.

To illustrate the preceding report, *Plate A* represents a perspective view of a standard pneumatic fire-alarm equipment as installed in a building, showing (1) the thermostats, (2) the iron pipe conductors, (3) the annunciating box, and (4) the electro-transmitter or generator. The latter is con-

nected to the local telephone circuit by three wires, so as to be short-circuited under ordinary conditions (in order to avoid making any resistance in the circuit); but upon the operation of a thermostat, the relative positions of the generator and telephone become reversed, thereby short-circuiting the latter, but only for the predetermined interval in which the telegraphic alarms are transmitted.

To indicate the security of such circuits, as afforded by the modern type of telephone subway construction, there is shown in the same plate a perspective view of the individual metallic circuit as it enters the cable box on the distributing pole, and thence goes underground, as shown by the view of the cables in the man-hole, including ducts and conduits. In addition to the permanence of such construction it possesses the advantage of the frequent test of each circuit as afforded by the almost constant telephonic communication over same, without, however, such use interfering with the automatic transmission of telegraphic alarms, when necessary.

Plate B shows a generator of the alternating current type, the alarms from which are received by the operator at the exchange (and re-transmitted), as distinguished from purely automatic transmission, when direct current generators are used at the subscriber's building, and correspondingly wound relays or automatic switches at the exchange.

Plate C represents the local annunciating box with separate pipes and shutter drops to correspond with the respective floors or apartments. A circuit-breaking device of the usual type is contained therein, so that it can be connected in series with any existing closed circuit, such as a city fire-alarm circuit, district telegraph, or private metallic circuit running to a central station, either in addition to the telephone exchange connection, or independent of it, where for any reason the latter cannot be procured.

Fig. 1 is a vertical section of the thermostat or actuating device in the normal condition; *Fig. 2* is a vertical section of same in operative connection, and *Fig. 3* is a side elevation in perspective. The respective parts are lettered in detail, as follows: *A* is a small cap that fits over the outlet

or nozzle, and has inverted lugs for the purpose of retaining the contained check-valve, when the latter is forced outward from the internal air pressure; *B* is the nozzle, with stand-

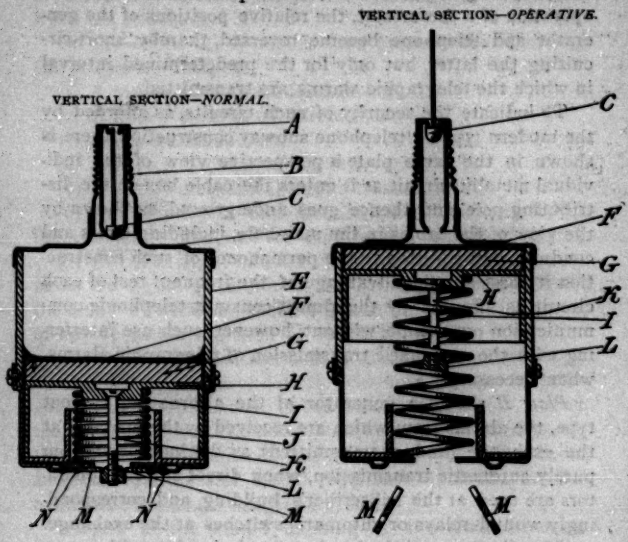

FIG. 1. FIG. 2.

ard pipe thread (1-8) for screwing the thermostat into pipe fitting; *C* is a gravity check-valve, which yields to the internal air pressure, but resists it from any other thermo-

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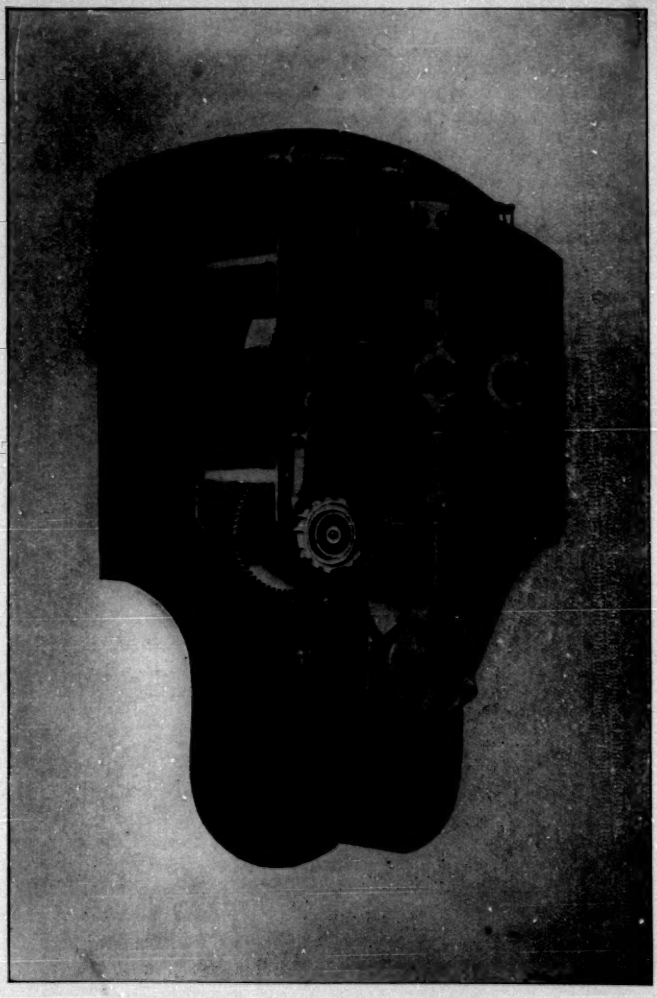

PLATE B.—AUTOMATIC MAGNETO GENERATOR.
(DIMENSIONS OF WORKS, WITHOUT CASE, 7 x 13 INCHES.)

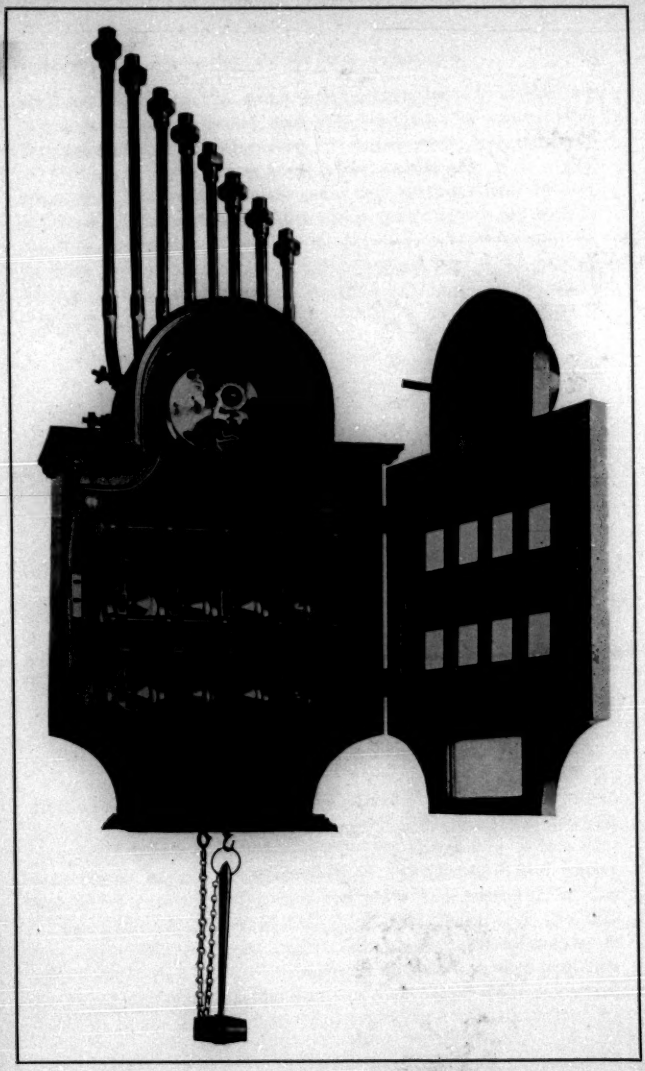

PLATE C.—AUTOMATIC ANNUNCIATING AND MANUAL SIGNAL BOX.
(DIMENSIONS OF WORKS, WITHOUT CASE, 9 X 13 INCHES.)

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stat connected to the same conductor pipe; *D* is the top cap over the air cylinder, and is brazed at the joints; *E* is the cylinder or air chamber of thermostat, the contents of which are normally at atmospheric pressure; *F* is a paraffine-wax seal, which fuses from the external heat in case of fire, and thereby lubricates the piston motion, as well as renders the same air-tight; *G* is an asbestos washer or packing, boiled in melted paraffine before use; *H* is a loose-fitting piston or plunger, cylindrical in shape, so as to be

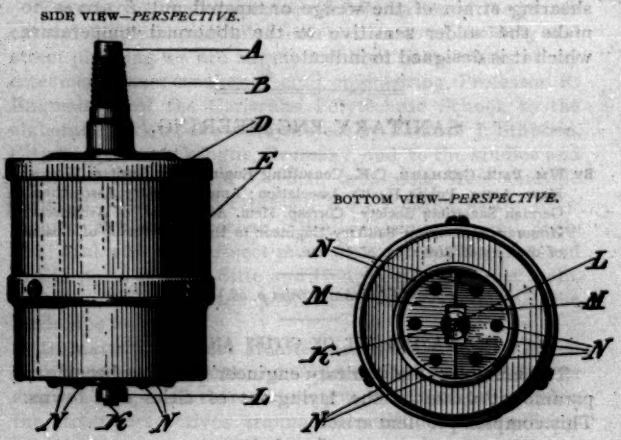


FIG. 3.

guided in movement; *I* is a normally compressed steel (piano wire) spring, specially drawn and tempered for the purpose; *J* is a cylindrical guide for the same; *K* is a vertical screw or rod in the center of the spring *I*, and keeps the latter under compression between the piston *H* at the upper end and a tapered nut *L* at the lower end, the latter being held at right angles, like a shoulder, by means of two halves of a disk *M*, which are retained in this position by being soldered to the base of the thermostat with the fusible metal *N*. When the resistance of the latter is

diminished by the heat of an incipient fire, the two halves of the disk *M* spread apart from the force of the shearing strain exerted by the wedge or tapered nut *L*, thereby permitting the latter to pass between, and the spring *I*, consequently, to push the piston and washer forward and compress the contained air of the cylinder. The possibility of premature rupture of the fusible solder *N* is resisted by a circular ridge or abutment at the circumference of the two halves of the disk *M*, while, on the other hand, the constant shearing strain of the wedge or tapered nut *L* serves to make the solder sensitive to the abnormal temperature which it is designed to indicate.

SANITARY ENGINEERING.

By Wm. Paul Gerhard, C.E., Consulting Engineer for Sanitary Works; Mem. Amer. Public Health Association; Amer. Forestry Association; German Samaritan Society; Corresp. Mem. Amer. Inst. of Architects; Honorary Consulting Sanitary Engineer to the Department of Health of the City of Brooklyn, N. Y., etc.

[*Concluded from p. 68.*]

THE LAYING-OUT OF CITIES AND TOWNS.

The municipal and sanitary engineer's services become of paramount value in the laying-out of cities and towns. This complex problem arises:

(1) When new towns are founded.

(2) When, owing to the tendency of men to congregate in cities, these grow so quickly as to require the extension of their limits by the addition of new outlying districts.

(3) When the alteration of the older parts of a city becomes necessary, owing to the increased internal traffic which requires the extension or widening of streets, or when, as in European cities, the abolishment of fortifications in old towns and the tearing down and planing off of fortified walls causes a sudden growth and expansion of the town, and calls for a reconstruction of its narrow streets, simultaneously with the building up of its outer districts.

In all such cases the actual work of extension, in whole or in part, should be carried out under a general, well-considered plan, and under the guidance of certain practical as well as æsthetic principles. We must confess, at the outset, that little work of the kind has, in the past, been done in the United States in the way suggested, for, as a rule, American cities grow in a haphazard fashion and often so quickly as to render the study of the problem and the preparation of plans out of the question.

For a learned and systematic consideration of the practical and æsthetic principles involved in town building and street planning we are largely indebted to the works of my esteemed former teacher of civil engineering, Professor R. Baumeister, of the Carlsruhe Polytechnic School, to the elaborate work on the same subject by Baurath J. Stübben, City Engineer of Cologne, Germany, and to the studies and labors of two eminent German architects, Herr Camillo Sitte, of Vienna, and Professor Karl Henrici, of the Polytechnic School at Aachen. While Baumeister and Stübben deal with the subject more from an engineering and health point of view, Sitte and Henrici discuss street architecture chiefly from the position of the æsthetic and the landscape architect.

In matters of street architecture there is a vast difference between European and American cities. The former are, as a rule, much more interesting, the sights are grander, the street perspectives are more beautiful and ever-changing, the impressions of the vivid and varied traffic are more lasting; monumental buildings are placed to better advantage; waterways are more picturesque, and more glimpses are afforded of gardens, parks and rows of trees used for the ornamentation of the streets. Compared with European streets, the American city streets lack architectural effects; we have too many dull, stupid and monotonous rows of houses, each house being identical with its neighbors, and in the business portions the ugly sky-scrapers of many stories shut out the light of day, the blue of the sky and the pure air of heaven, while there is a lack of prospects and outlooks of ever-varying views, and of expressions and im-

pressions of beauty. In all this, I firmly believe, we have very much to learn from the older cities of Europe.

The planning of extensions of existing cities and the laying out of new towns require a very careful consideration of the numerous engineering works located both above and below the streets, and of the constructive, sanitary and æsthetic features of streets, squares and buildings. Broadly speaking, the requirements relate to traffic, to building and to sanitation. It is fortunate that in street planning and street architecture, the æsthetic and art requirements coincide with the requirements of hygiene. Everything in this line which helps to embellish a city has also sanitary advantages. I, therefore, crave your pardon, if, in the following, I mention matters which at first blush may appear to you to be more of an architectural nature, or belonging to landscape rather than to sanitary engineering.

In developing the plan of a city we should consider the mode of living of the inhabitants and the character of its habitations and other buildings. Regarding dwelling houses we may distinguish the open or detached, and the closed, block or terrace arrangement of houses. A city may generally be divided into several districts, such as (*a*) the manufacturing districts, with factories, industrial establishments, warehouses for wholesale trade, and bonded warehouses; (*b*) the workingmen's districts, comprising laborers' dwellings or cottages, and, in some cities, the tenement-house districts, although it is to be hoped that tenement-houses will ultimately disappear, and that the aggregation of large numbers of people into small, dark, overcrowded and unhealthful apartments will cease; (*c*) the shopping districts, containing the large shops and stores, generally located on the main thoroughfares of traffic, and constituting the retail business section of cities; (*d*) the business section proper, including the centers of wholesale and general business, the exchanges, the banks, the chamber of commerce, the post-office; (*e*) the sections in which the railroad terminals are located, including travellers' headquarters, hotels, express offices, etc.; (*f*) the residential districts, made up by the mansions of the rich and by the dwellings of the well-to-do people.

In laying out the principal thoroughfares on the general plan, we should carefully consider the size, character and the centers of traffic, as well as the radial, diagonal, longitudinal and belt traffic. We should make provision for the traffic on foot, for heavy truck or wagon traffic, for carriage, cab and hack traffic, for equestrians, for stage lines, and tramways, whether propelled by cables, electricity or by horses; finally, we should include the steam railroads and transportation by water, and endeavor to establish some well-considered system in the traffic of a city.

The principal axiom to be followed is that city streets should be laid out not only for traffic, but also with an eye to permanent beauty, by bringing architectural structures and sculptural monuments into agreeable position or into effectual grouping. The requirement that engineering and landscape architecture are to be combined should never be lost sight of in street planning. It is of still greater importance in the laying out of boulevards and of parks, drives and speedways.

The width of streets should be determined according to their importance or the probable amount of traffic. The grade or longitudinal profile, the cross section of the street, its surface drainage, the facility for building, all these matters should be considered.

The rectangular system of streets, so prevalent in American cities, does not merit approval on æsthetic, much less on practical grounds. In a skilfully laid out network of city streets, straight lines of too great length are avoided as being very monotonous and as wearying the eye; gentle curves or variations in the width help. Intersections of thoroughfares should be utilized and set aside for public buildings, such as railroad stations, theatres, churches, museums, banks, telegraph and post offices, court-houses and markets. Schools and hospitals should be relegated to the quieter side streets. Likewise should the street perspectives be beautified by artificial ornaments, monuments, and sculptural works set with a good background, or graceful statues, or by water jets and fountains, or by arcades. On important street crossings and squares there should be

provided landing places affording safety for pedestrians crossing a thoroughfare crowded with vehicles, and these landing places may be adorned with candelabras or with pavilions, with fountains or public seats and benches, or with graceful shrubbery. The intersection of important streets should be utilized for squares, and the artistic embellishment of these should always be considered. Advantage should be taken of the natural configuration of the ground in the laying out of streets. The uneducated eye must be taught to appreciate the beauty of undulating ground, in which opportunity is afforded to look down from the high points on beautiful layouts of commons, on public parks, or to look up from the lower points to buildings or monuments on commanding sites. The beauty of many an imposing architectural structure is, in American cities, lost, owing to the impossibility of looking up to the building.

The division of the cross-section of wide streets into footpath, roadway and boulevard, offers opportunity for landscape effects by providing special promenades in the center, with rows of shade trees or shrubbery and flowerbeds, and the traffic may be benefited by separating the carriages, the horseback riders and the heavy teams and trucks.

Regarding the proposed width of streets and the distance between streets or the depth of the blocks, it should be noted that too great width of carriage-way is undesirable, as it tends to increase the dust and dirt, and the cost of street maintenance. Likewise should the distance between streets be limited, for very deep blocks are undesirable and lead, where the land is valuable, to a building up of the interior of blocks with rear dwellings, or with factories, workshops and storage buildings. All buildings should have a frontage on the public street, and the rear part of lots should be utilized for yards; or better, the center of the block may be laid out in well-kept private gardens or pleasure grounds, with low and open dividing lattice fences, or else all the yards in a block may be combined into one large open space, with drying yard, playground and lawn, thus providing plenty of pure air and daylight to the rear

of our dwellings. The ideal mode of building from a sanitary point of view is the detached method, but it is only adapted to the suburbs and outlying villa districts of cities.

Public squares in cities may either serve for general traffic, or for meeting places, for markets, for approaches to prominent buildings, such as city halls, churches, synagogues, theatres, museums of art and of natural history, or schools, or else they are intended for adornment and as locations for monuments. Open squares in cities have a distinct sanitary value, because they afford breathing spaces. If they are laid out as a public garden, common or park, with lawns and flower-beds, shrubs and trees, benches and seats, they afford opportunity for recreation, constitute playgrounds for city children, they promote the healthfulness of a city by lessening the street dust, removing the street noise, and by maintaining a purer atmosphere. Squares and parks are, therefore, aptly termed the "lungs of a great city."

In addition to promenades liberally planted with trees, and open spaces and public gardens, a large city should have public parks and airing grounds, to afford its inhabitants opportunity for taking exercise in the open air. Where possible, the parks should be connected by boulevards, and these, laid out by a clever landscape artist, may afford pretty outlooks on the city, onto the broad expanse of its surroundings, or a distant view of the water.

As regards their location in relation to the plan of the city, all public and important business buildings and structures may be divided into three classes. The first class embraces buildings which are business centers and which *centralize* the traffic, such as city halls, court-houses, exchanges and bourses, banks, main post-offices, houses of parliament, or capitol buildings, judicial buildings, municipal government buildings, halls of record, telegraph and telephone headquarters, hotels, museums, libraries, terminal depots, railroad stations, ferry-houses and docks for arrival and departure of steamships. To the second class of buildings belong those which have a tendency to

distribute traffic, such as sub-stations of post-offices, public telegraph and telephone stations, churches, schools, police stations, open and covered market halls, exhibition buildings, theatres, circus, concert halls, club-houses, other places of amusement, fire-engine houses, people's public baths and wash houses, asylums, livery stables, also buildings in public parks. The third class consists of buildings which should be confined as much as possible to *special outlying sections* of a city, and of these I mention military barracks and military drill grounds, jails and prisons, hospitals, reformatories and orphan asylums, cemeteries and mausoleums, abattoirs and slaughter-houses, cattle and stock-yards, noxious trades, gas works, waterworks pumping stations, reservoirs, standpipes, settling and filtering basins, sewage pump and disposal works, garbage dumps and the like.

In European cities generally much more attention is paid to a good and suitable selection of sites for monumental and public buildings than here. It is unusual to find a church, or a theatre, or a school, located in the middle of a block. Open spaces on at least three sides are required for churches, museums, schools, hospitals and theatres, with the incidental advantage of gaining better light and air and better approaches to the buildings, and of having better and more numerous exits in case of danger from fire or a panic.

The water-fronts of harbor towns or of cities situated on the banks of a river are also worthy of embellishment and improvement. Much remains to be accomplished in American cities in this respect, for here the water-fronts are usually the least attractive portion of a city, whereas in cities of the continent the reverse is often the case. Water-courses or canals flowing through the heart of cities should be kept clean, and may serve to beautify the same, if all liquid or solid filth is carefully excluded, if the banks are rectified and protected, if they are hemmed in by well-built stone embankments, with gardens or parkways, and if picturesque and ornamental bridges are carried over the same. Natural coves or basins may be made points of great attraction, as every one will concede who has ever seen the beautiful Al-

ster-basin in the city of Hamburg, Germany, with its boulevards and garden banks, its hundreds of row-boats, sail-boats, and little steamers on the water, travelling to and fro, and enlivening the landscape.

Some general and sanitary requirements of a well-studied city improvement plan are the following: good location; protection against high water and floods of rivers; dryness and cleanliness of building soil; ample means for traffic, on land and by water; facility for future enlargement; ample public squares, gardens and parks; well-lighted streets and well-laid and well-kept pavements; perfect drainage, sewerage and sewage disposal; easy mode of removal of refuse and destruction of garbage; healthful habitations; freedom from soil contamination; prevention of pollution of rivers, lakes, coves or water-courses; pure drinking water supply and ample supply of water for all other purposes; ample provision for plenty of light and air in the streets, in the centers of house-blocks and in the habitations; avoidance of smoke nuisance, and noiselessness of streets.

The execution of the improvement or enlargement plan for a city requires a large number of well-devised engineering and architectural structures, above as well as below the street surface. For purposes of a water supply a city needs a distributing system of pipe mains, with shut-offs, house taps, street hydrants for fire department use and for washing and sprinkling the gutters and streets, also public drinking fountains, horse-watering troughs, ornamental fountains, etc. For purposes of sewerage the city requires underground pipes and masonry conduits, man-holes, inlets, flush-tanks, house connections, gutters, catch-basins, also public urinals and public water-closet accommodations. Then again, a city requires means and facilities for public street- and house-lighting by either gas or electricity, involving a distributing system of gas pipes, mains, sub-mains and branches, valves and siphon boxes; house and street lamp services, street lamps and candelabras, and, on the other hand, electric wires or cables, subways and electric light poles. For facilitating intercommunication, a city requires telephone and telegraph wires for the public, for the police

and fire departments, with fire alarm boxes, telegraph and telephone stations, and pneumatic conduits for parcels and mail service. Other underground conduits for the distribution of light, heat and power, comprise steam mains, pipes for water, fuel or natural gas, conduits for hot water and for compressed air, electric cables and pipes for distribution of cold refrigeration. On the street surface the traffic requires pavements for carriages and trucks; sidewalks for pedestrians; roads for equestrians; horse, electric and cable roads, with their underground cable and trolley wire conduits—overhead wires should not be countenanced—elevated roads and underground railroads, etc.

The street traffic of a city also requires certain accessories for public information and public convenience, such as house-numbers, street-signs, warning-signs at grade crossings (I may say here that railroad crossings on a level with streets should be abolished in well-laid-out cities), street-clocks, columns for advertising purposes, fire-alarms, signal boxes, columns for weather indications, waiting pavilions for street railways or steamers, public conveniences, lamp-posts, letter-boxes, news stands and pavilions for sale of refreshments, music pavilions, seats and benches, etc. There is no reason why these utilitarian devices should not serve as tasteful embellishments of our streets by having them designed in an artistic manner.

It is finally necessary that a city improvement plan be carried out in accordance with well-framed building and sanitary regulations. Such building regulations refer principally to construction and stability, to safety from fire, to traffic considerations, and to healthfulness of buildings. Those relating to the salubrity of buildings, and to maintenance of the public health, are doubtless of the greatest importance. The rules should limit the size of the area of lots available for building; they should regulate the height of buildings in proportion to the width of the street, to secure light, air and sunshine to the houses. They should control the period when newly-finished dwellings are to be occupied, and should prohibit cellar habitations. Other regulations should have reference to the filling-in material

used for low building lots, to the drainage of low land subject to overflow, to the maintenance of cleanliness on vacant lots in cities, to factories, workshops, stores, and to noxious trades, to schools, places of assembly, like theatres, lecture halls and churches. In order to facilitate building operations, it may be wise to apply building regulations of less severity to the outer districts of a city, or, in other words, to arrange for several distinct building zones.

The engineering works enumerated and described form together a large sanitary system, which must be planned by sanitary engineers to establish safeguards for the public health in centers of population, and which, assisted by a wise sanitary administration, helps to diminish the death-rate of a city.

I had intended to speak to you more fully about matters connected with the general sanitation of towns, some of which I have just been able to scan very briefly, such as the relations of sunlight and sun warmth to health, the avoidance of outdoor and indoor dust, the prevention of the pollution of town air by smoke, vapors and fumes, the planting of trees in wide streets, the laying out of gardens, public squares and city parks and their sanitary benefit to the town dwellers, the means of transportation, storage and sale of the food supply, and other topics, but the time at my disposal does not permit more than the casual reference to these sanitary problems. Nor can I discuss to-night the city graveyards, cemeteries, mausoleums, crematories and other modes of preservation and disposal of the dead, nor the drainage of swamps and malarious districts, the prevention of inundations and storm-floods and of drought, the sanitary influence of forests, the benefits due to forest culture, and the objects of city and village improvement and sanitary associations, all of which will at some time engage the sanitary engineer's attention.

Again, much as I would feel inclined to, I cannot touch to-night upon the sanitary engineer's duties in relation to habitations. The sanitation of the dwelling, the protection of buildings against the elements, the problem of hous-

ing the poor, tenement-house reform, the sanitary features of schoolhouse construction, the proper planning and arrangement of hospitals, of prisons, jails and military barracks, the establishment of people's baths in populous city districts to further bodily cleanliness and health of the working people, the arrangement of markets and of abattoirs, the disposal of dead animals, the construction of mortuaries and city morgues, the fire protection of buildings and of cities, the safety of audiences in theatres and general theatre hygiene—these are all matters pertaining in whole or in part to sanitary engineering.

Industrial hygiene, the sanitation of workshops, the prevention of machinery accidents in manufacturing establishments, the regulation of noxious and offensive trades, the abolishment of public nuisances, the healthfulness of summer hotels and summer resorts, present problems which it is often the business of the sanitary engineer to solve.

The hygiene of the travelling public requires, not only provision of comforts and conveniences, but, above all, of safety and cleanliness. In hotels this means unobstructed fire escapes and fireproof stairs, located, not around, but away from, the elevator shafts, perfect cleanliness of rooms, beds and bedding, bathing facilities, well-kept toilet rooms, safety from sewer gas in sleeping apartments, freedom from coal gas due to stove dampers, avoidance of gas leaks due to defective gas fixtures and the filtering of the water supply, and in particular of the table water.

Public conveyances, in which travellers are often carried for long distances huddled close together, need sanitation as much as our homes. Surface, street and elevated railroad cars should be thoroughly washed, cleaned and aired every night. The ventilation of railroad coaches, of sleeping cars, of railroad tunnels, of ferry boats and of steamship staterooms and berths afford sanitary problems which are not always easy to solve. The luxurious sleeping cars, in particular, could be much improved if more attention were paid to cleanliness and sanitation rather than to decoration and embellishment. Means of ventilating cars are often

absent, or, where they are provided, they are not effective, because they are not rightly handled by the train hands. Among more palpable defects I mention defective lighting, overheating, lack of cleanliness and of ventilation, unclean water tanks, with ice and water of doubtful purity and often mixed together, bad arrangement of car-hoppers, objectionable water-supplied pan-closets in compartment cars of vestibule trains, etc. There is in all cases some danger of the transmission of disease, such as typhoid fever, or consumption by the sputum of invalids. Railway and ship sanitation include much more than this, as you will admit when I recall to you the disgraceful unsanitary condition of many railroad stations, and when I remind you of the crowded steerage quarters on emigrant vessels.

A large part of the practice of a sanitary engineer refers to sanitary inspections, whether examination of houses, or inspection of future building sites for institutions, or sanitary surveys of cities and towns. His acquirements also render him well qualified to assist in drawing up building laws and sanitary ordinances, to see to their proper enforcement in the position of sanitary, or building, or factory inspector, or to prepare in the office sanitary maps, profiles and diagrams of mortality in its relations to meteorological and sanitary conditions.

Another part of his work consists in rendering expert services in cases of litigation pertaining to sanitary works or sanitary patents. To give testimony as an expert witness in court is not always an agreeable duty, particularly under the custom prevalent in the United States, under which experts are engaged by both the plaintiff and the defendant. It is far preferable, to my mind, that experts be retained by the court only, as is the rule in some European countries. I also hold that it were better if experts in sanitary engineering cases were confined to testifying to facts only, and not required to answer hypothetical questions. In any case, they should limit themselves to testimony relating to sanitary engineering questions, and decline to enter into a discussion of problems belonging to sanitary science or the germ theory of disease. Even a well-qualified and learned

sanitary engineer should not offer opinions in court cases as to what may or may not be injurious to health. He should leave this to the medical officers, to the sanitarian, the biologist, and he should confine himself entirely to the constructive side of such works as health officers require for prevention of illness or to increase salubrity. Viewed in this light there is quite a distinction between a sanitary engineer and a sanitarian, which, in cases of litigation, the judge, as well as the attorneys who plead the case, should recognize.

Then again, I must remind you of the special work and duties of the sanitary engineer in case of sudden outbreaks of epidemics, or of sudden calamities or great disasters in civic life, such as earthquakes, river floods, and destructive conflagrations; and of the services which may be rendered by sanitary engineers in time of war, such as the erection of temporary hospitals for the wounded, the housing of soldiers in tents, the maintenance of cleanliness in the camp, the sanitation of battlefields and the prevention of war pestilence.

I trust my audience may have gained a tolerably clear insight into the numerous duties of the new profession; and now, having defined sanitary engineering and gained some knowledge of the education and the practice of the sanitary engineer, and of the problems which engage his attention, we are enabled to answer the question: "Who is not a sanitary engineer?" in the true sense and meaning of the term.

No one should be entitled to the name of "Sanitary Engineer" unless he is amply qualified, by study, special training and practical experience, to offer sound advice in all problems arising in his profession. The mere fact that a man is qualified in a single special branch, for instance, in house drainage or the plumbing work of buildings, should not entitle him to be regarded as a sanitary engineer.

I am quite aware of the fact that, in making this statement, I am stepping on dangerous ground, and that there will be some who may not agree with me. I do not believe in mincing such matters, and I do prefer always to call

things by their right names. Misuse of terms is misleading. A builder or contractor is not an architect, but the architect may, in certain cases, be a builder. A druggist or apothecary is not a doctor, though an educated physician may be, at times, a dispensing chemist. So likewise, a man who does the plumbing work of buildings, or who takes contracts for laying drains or sewers, or who confines himself to repairing or altering defects in house drainage, is not thereby qualified to be considered a sanitary engineer, but a sanitary engineer may, and often does, plan or carry out works of house drainage and interior plumbing arrangements.

A man does not become a physician by the mere act of hanging out a sign, on which he styles himself "M.D.," neither does a man become a sanitary engineer by merely adding these words to his trade sign, when he has obtained a license to run water pipes or to lay sewers, or when he is appointed inspector of nuisances. The innocent public, however, may oftentimes be misled by signs of ambitious tradesmen, such as "Plumber, Gasfitter and Sanitary Engineer," or the still more pretentious sign, "Plumber and Consulting Engineer for Hydraulic and Sanitary Works."

I do not wish, however, to be misunderstood, nor that my words should be misinterpreted or misquoted. Nobody has a higher appreciation of intelligent and skilled mechanics and craftsmen than I, and it is far from me to underestimate the good work done by conscientious men of the trade. But the difference between a trade and a profession cannot be bridged over or eliminated by devices merely calculated to deceive the public. It is just as erroneous to call a man, or to take a man to be, a sanitary engineer, who has had no general engineering training, and whose knowledge and skill is confined to house drainage and plumbing, as it is to think a man cannot be an engineer because he does not build or run engines. And to go a step farther, physicians, when they have made a special study of preventive medicine and sanitary matters, should likewise not be considered sanitary engineers—the term "medical engineer" has even been compounded for the purpose—for they lack the tech-

nical experience and training absolutely required to qualify them for carrying out works of sanitary engineering.

To reiterate: Just as in medicine the eminent specialists must be physicians proficient in general medicine, so in the profession of engineering *the sanitary engineer should be a well-trained civil engineer.*

A few words, in conclusion, in regard to the *general* qualifications of the sanitary engineer. To my mind, he should be a man with the broadest possible general culture. He should not only have a thorough knowledge of his profession, but he should combine with it good business capacity. He should be faithful, conscientious, accurate, honest, trustworthy, sound in judgment and of absolute integrity of character. He should respect his brother engineers in order to win their respect. In order to deserve universal respect, he should, if he has decided to practise for himself, avoid sensational writing or advertising, and confine himself, if he is building up a practice, and is obliged to seek work, to such legitimate advertising as he may accomplish by insertion of a professional card in engineering journals; or by the opportunities which present themselves to him to demonstrate his qualifications and skill in works carried out from his designs or under his superintendence; by original contributions to the technical and engineering press; by the dissemination of essays, or by lectures. Much of the sanitary engineer's work is necessarily of a missionary character, as the public must be educated to appreciate the beneficial effects of sanitation. Not a little of his work requires patience and perseverance. It is, as a rule, up-hill work, until he finally reaps success and the merited reward of a widespread reputation.

Once a reputation is established, the sanitary engineer should be much more closely identified with public matters than has been the case in the past. Among the learned professions engineering occupies the foremost rank, and sanitary engineers in particular, are, by reason of their special training, exceptionally well fitted to be represented in City, State and National Boards of Health, in Boards of

Education and of Charities, in City Councils, city improvement societies and on citizens' committees.

The sooner the fact is recognized in the appointment to municipal offices or boards of public works, that engineering is not politics, the sooner will the reform movement, which has been so happily inaugurated in my own city, spread to other cities and bear good results.

OUR PENNSYLVANIA FORESTS.*

By Dr. J. T. Rothrock,
Secretary of the Pennsylvania Forestry Association.

The lecturer was introduced by the Secretary of the Institute and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

As a nation, our resources have usually been in advance of our needs, or in other words, there never has been a time when our capacity for production has not been in excess of our consumption. When we read of famine in other lands and think that in all our national life no such monster has ever stalked over any considerable portion of our country, we imagine that we are a peculiar people and under a special Divine protection. Anticipating no shortage in the future of any of the necessities of life, we have become reckless in the expenditure of what we have. We have absolutely lost sight of the fact that those who follow may, nay, must inevitably, suffer from our extravagance. Indeed, it is hardly too much to say that most of our legislation is based upon the present and takes almost no account of the future. Hardly a statesman whose name adorns our national records, has fairly looked into the future and shaped a specific policy, to anticipate wants which must press upon us unless we provide in advance for their advent. We have swept the buffalo from the plains, the fish from the streams,

*A lecture delivered before the Franklin Institute, January 4, 1895.

and are, as fast as possible, removing the forests to an extent which older nations have pronounced dangerous.

Before we consummate this last folly it may be well to ask ourselves just what our relations with the trees are. I shall consider this from three standpoints: (1) Forests as holding soil; (2) Forests as making soil; (3) Relation of the forests to the atmosphere; and finally shall draw some general conclusions from the statements previously made.

Forests retain, or hold, soil in its existing position. To illustrate this let me call attention to a hillside in Mifflin County, Pa. When I first knew that ground it was covered with timber. There was not a single gully upon its steep surface; and to this day, upon one end of the same hill, where the timber remains, no sign of wash appears. At present, from one end to the other of the timberless part, the hill is literally seamed and scored by gulches. Its value, as farm land, is absolutely nothing. Nor is this all. The soil, gravel, and even rocks, have been swept like an inundation to overflow and destroy the good soil on the flats below. Thus a two-fold injury has been wrought, one which threatens with each successive year to become worse unless arrested—at a considerable expense to the owner.

Let us take another illustration. Here is a scene in the Valley of Long Run, in Clinton County. The signs of a destructive inundation are everywhere apparent. Huge boulders and massive angular fragments of rocks dot the course of the stream. Fresh landslides show where the retaining soil below has been washed out. If you follow down the course of the stream you will see where the farms have been overflowed, where the original channel has been changed, a new one cut out, and where buildings have been undermined and swept off in the flood, involving a loss of human life which was sickening in its details.

Now return to the head of the stream and what do we find? A principal valley whose steep sides indicate a rapid delivery of water; a number of lateral, smaller valleys, with equally steep sides, and in every one a mountain stream, whose quick flow tells plainly enough with what impetuosity the water is delivered to the main channel.

From almost every part of this valley of Long Run, from even the remotest highlands, whose slopes send their contribution to swell the flood, the surface is as bare as fire and axe can make it; or where the barrenness is not already absolute, the lumberman is at work to complete the naked picture.

Do not misunderstand me. I am waging no war with the lumberman. He has his vocation, and the prosperity of the country demands his product. I am simply considering the facts.

Let us shift the scene, and go over into Rose Valley, in Lycoming County. As I drove through it I was struck by the fact that where the stumps still remained in the fields there were signs of good crops; but when I came to fields which were clear of stumps, and thereby showed that they had been longer under cultivation, generally, the crops appeared to have been smaller. In a word, there was less soil in the old fields than in the newer ones. Then when I came to the foot of the slopes I found what had become of the soil. It was washed out, and the stony surfaces in the older fields showed that it had gone, and explained why the crops were short.

It hardly seems necessary to devote any more space to a discussion of a principle which should be clear enough from the illustrations already given.

Let us now consider the second proposition—*that forests make soil.* First of all, we will note the growth of the mangrove thickets on the coast of Florida. The mangrove is a seaside plant in tropical regions clear around the world. It has its marked peculiarities, and among them is the one that the parent tree holds on to the seed, not only until it is perfectly matured, but until it has well begun its growth. When cast off, the young mangrove is a plantlet, or treelet, about a foot long. Thousands of these are yearly dropped from the older trees on the coast of Florida into the water and carried off by the wind and tide. Perhaps at low tide some of these are stranded on an oyster reef; where the soil is absolutely bare of any sign of what you would consider soil. Nothing but the crevices in a surface which is

covered by the repulsive slime of the ocean exists to offer the young mangrove a foothold. This, however, is sufficient. It is the one plant specially prepared to fill that place, and, once landed, it begins to establish itself and to grow. Nor is this all. No sooner are the roots fairly fastened, and the first trunk two or three feet high, than from the newly formed branches there are sent down hanging "air roots," which attach themselves to the reef as the parent stem had already done. Let us shift the scene and note the vigorous growth of the mangrove on the tropical shores of Jamaica. Near Port Morant one may find forests of this tree possibly seventy feet high. Over the tangled mass of roots one may walk for miles, a foot above the water, without coming in contact with it. This tangle of root and stem is not without its purpose in the general economy of nature. When the tree has attained its growth and fallen, to return by decay to the inorganic condition, it is in the eddies formed by these roots that the matter is retained. By slow degrees, in the course of ages, soil begins to appear above the surface of the water. Slime is buried beneath soil and on the rising earth, forests of a new kind, and possibly of greater utility, may appear.

Or, if we study the bald cypress, a lesson no less impressive is taught. We are quite too apt to think that this tree is specially fitted for bayous and mud-banks and will grow nowhere else. The fact is, the bald cypress is a tree of pliant constitution, well adapted to a wide range of conditions. I have seen it thriving where it grew up out of an asphalt pavement, and also photographed vigorous specimens of it where it stood out in the muddy water of the James River. When we find it in such positions as the one last named, the proper view is that it grows there because it is free from competition by occupying a place in which no other tree of the region will flourish. In the Southern States it forms just such forest masses as the mangrove does in Jamaica, except that it produces no such thickets of "air roots." These trees rise out of the brackish or fresh water, grow, mature, fall, decay, and out of their remains fresh soil is formed to produce dry ground for other crops.

One might be allowed here to call attention to the fact that on the soil formed by the mangrove and the bald cypress some of the most important crops of the world are produced. Indeed, a mangrove thicket strikingly illustrates some of the earlier features of "world-making." Its density, its emergence from the bosom of the ocean, produce an impression which is strikingly at variance with the ordinary course of things in temperate and sub-tropical regions to-day. Furthermore, when we consider the disappearing hemlock forests and recognize the possibilities of modern chemistry, it is hard to estimate what advantages it will place in the hands of the tanning industry, for it contains an enormous percentage of tannin.

No fact of science is better established than that the presence of moisture in the air, over any region, in temperate latitudes, tends to prevent the escape of the earth's heat. Professor Tyndall most forcibly explains that aqueous vapor in the atmosphere of England is as necessary for the vegetable life of that country as clothing is for man. It is equally well attested that plants in a vigorous condition are, during the growing periods, very active in giving off moisture to the air by transpiration, that they even transpire more than is received by the roots, which, of course, indicates another source of supply than the roots. The quantity transpired is very variable for different plants and under different atmospheric conditions; but from known facts, it is well accepted that the volume is enormous. The presence of this enormous body of water in the atmosphere must be accepted, and, if there, its potency must be acknowledged as a factor in climate, if not locally, then generally. It can hardly be doubtful that the change of a country from a wooded to a treeless condition must be accompanied by a change of climate, of moisture in the air, and consequently of temperature.

It appears that in our latitude the result must at least be a climate of greater extremes—extremes which would possibly affect the production of what are now important crops. Strict science has not the whole field to itself, and the observations of intelligent lay observers are at least

worthy of a respectful hearing. Some of these observers, whose remembrance extends back to the time when the country was under more positive woodland conditions, assert, as their opinion, that such changes have already taken place. For example, they assert that the period during which hay may be made has been appreciably reduced during the last half century. Owing to drier atmosphere, they say the grass must be cut at once when ripe, or be damaged as a forage by standing. I neither accept nor deny the statement, but content myself with remarking that the observation is entitled to a hearing, and that it opens the door for a productive line of meteorological research.

From the foregoing it would appear as if the relations between the surface of the country and the forests were most intimate and important. The natural sequence to this conclusion would be the inquiry: What proportion of the State should remain under forest cover? For Pennsylvania, with which we are most concerned, it would be safe to say that forests should be retained wherever they would be the most remunerative crop. This at once divests the subject of all sentiment, and places it under the same common-sense management which we accord to our crops, and it also places forestry where it should be, under agriculture. The mountain axes of the Commonwealth, the steeper ridges, the lowest swamps, where drainage is difficult, worn-out fields, where, owing to steep slopes and natural poverty of soil, it is impossible to retain enough of fertility in the soil to produce remunerative crops of the cereal grains, or even to maintain grass for dairy purposes—all these should be covered again with trees.

To this proposition there would be two natural inquiries. The first, "Is it possible?" The second, "Would it pay?" One may dismiss the first inquiry with the statement that forests may always be produced as a crop when accorded the care of a crop. It seems ridiculous to be obliged to reiterate that in Germany, France, Switzerland, Scandinavia and other European countries, forestry is as firmly established as any other branch of agriculture; but it appears to

be necessary, for to the average American the idea of producing forests is still little less than absurd. The idea is growing; but it will require years to firmly establish it *just where it is most needed.* The remaining inquiry, "Would it pay?" may be answered in two ways: first, does it pay to farm such land as we have indicated should be devoted to growth of forests; second, "Is there any other known way of utilizing these lands, unless they happen to have some mineral deposits?" It will not pay in one year, in five or in ten years; but it will pay, in the longer run, interest and principal on capital invested.

It is well, in this connection, to call attention to the following, which is part of a law now standing on our statute books:

"AN ACT

"For the encouragement of forest culture, and providing penalties for the injury and destruction of forests.

"SECTION 1. Be it enacted, etc., That in consideration of the public benefit to be derived from the planting and cultivation of forest or timber trees, the owner or owners of any land in this Commonwealth planted with forest or timber trees in number not less than 1,200 to the acre, shall, on making due proof thereof, be entitled to receive annually from the commissioners of their respective counties, during the period that the said trees are maintained in sound condition upon the said land, the following sums of money:

"For a period of ten years after the land has been so planted, a sum equal to ninety per centum of all the taxes annually assessed and paid upon the said laid, or so much of the said ninety per centum as shall not exceed the sum of forty-five cents per acre;

"For a second period of ten years, a sum equal to eighty per centum of the said taxes, or so much of the said eighty per centum as shall not exceed the sum of forty cents per acre;

"For a third and final period of ten years, a sum equal to fifty per centum of the said taxes, or so much of the said fifty per centum as shall not exceed the sum of twenty-five cents per acre;

"*Provided*, That it shall be lawful for the owner or owners of the said land, after the same has been so planted for at least ten years, to thin out and reduce the number of trees growing thereon to not less than 600 to the acre, so long as no portion of the said land shall be absolutely cleared of the said trees;

"*And provided also*, That the benefits of this act shall not be extended to nurserymen or others growing trees for sale for future planting.

"SEC. 2. The owner or owners of forest or timber land in this Commonwealth, which has been cleared of merchantable timber, who shall, within one year after the said land has been so cleared, have given notice to the commissioners of their respective counties that the said land is to be maintained in timber, and who shall maintain upon the said land young forest or timber trees in sound condition, in number at least 1,200 to the acre, shall, on making due proof thereof, be entitled to receive annually from the commissioners of their respective counties the sums of money mentioned in the first section of this act. *Provided*, That the first period of ten years shall be counted from the time that the said land has been cleared of merchantable timber, and that after the said first period of ten years, the number of trees upon the said land may be reduced as in the said first section is provided."

It is a striking example of the folly of men that they will pay taxes on unproductive land, maintain fences, and bestow their labor upon it, render it each year more and more impoverished and continue to do this in spite of the fact that it will yield them nothing in the end. This folly is the more striking when it has been shown, all over the State, that such a law as the above exists for the sole purpose of ameliorating the condition of those "small land owners" who need it most. But how shall one characterise the stupidity of a farmer who owns a few acres of half-grown oak on a barren, steep, hillside, with a slaty surface and a northern exposure, and who cuts it off to sell in a market which is on the very lowest round?

It is an old, threadbare argument, that substitutes for

wood will be found. The statement is doubtless true, and might have some weight were it not for the fact that new uses are also being found for it much more rapidly than the substitutes for it are. The plain undeniable fact is, that wood will always remain almost as much an article of prime necessity as water.

There is another aspect of the problem which may well be considered: rates of interest tend to become lower as countries become better settled and business reaches a condition approaching an equilibrium. Contrast, for example, the interest on capital invested in England, and in Oregon and Washington. The 8 per cent. almost invariably comes from the lands to the west of us, and the undoubted tendency is for good securities to command lower rates. There is an evident exception to this general rule. Our population is becoming more dense, our timber-land areas are becoming more and more depleted, until it requires no prophetic eye to see the practical obliteration of important lines of business in this Commonwealth. In other words, the demand is continually increasing, and the supply as certainly decreasing. The inevitable tendency must be to increase the value of standing timber.

Thus far no allusion has been made to the spontaneous restoration of our forests. It is probably safe to say that in no temperate region is this tendency more marked. I might even go further, and say that the quantity of wood which an acre will produce spontaneously each year is a perpetual marvel to the European forester. It seems to be equally a marvel to our own people that when once a forest is removed it is not succeeded promptly by another of the same kind. As a matter of fact, there is no more reason to expect a perpetual succession of the same kind of timber than there is to expect that, from a single sowing, men should reap a perpetual succession of the same kind of grain; and there is no more reason why the existing tendency should be used, as it often is, as an argument against tree planting than there is why it should be used as an argument against grain sowing. The very same methods which ensure the crop we desire in the one case, will ensure

it in the other, the chief difference being the time of maturing. It is vastly important that the widespread error in regard to our most important tree, or what was our most important tree, the white pine, should be corrected. There is no species in which the tendency to restoration by seed is more marked. Over the State, here and there, in numberless places, one may see thriving groves of this tree coming on; nor does there seem to be any acceptable reason why the coming crop should not be as good as the first, if sufficient time be allowed for the wood to fully mature. It is well known to experts that the white pine does not select the richest soil for its favorite place of growth. This only makes it the more valuable. The one great foe to the young white pine is the unrestrained forest fires. It seems to be a wretched public policy which permits land to lie for half a century unproductive after its white pine crop had been removed. What shall be said of the policy which declines even to protect the spontaneous bounty which nature offers, but allows fires, year after year, to destroy the coming timber crop?

I do not draw upon my imagination when I propose this question, but at this moment can point out extensive areas in this State, which are now a picture of desolation, but which, under a wise State policy, should have been on the verge of reaping a harvest worth millions of dollars for its second growth of timber. One of the shortcomings which will be hard for the next generation to excuse, will be that we have stolidly ignored their interests, so far as protection of our timber resources are concerned. Yet it must not be forgotten that the present generation is the first one, of civilised men, born on American soil, to whom a possible scarcity of timber, or an unfortunate train of circumstances growing out of that scarcity, has presented itself as a present pressing problem. To those who preceded us, the problem was what to do with the excess. Scarcity faces us, however, squarely.

We recognize clearly enough two aspects of forestry—individual and State forestry. Let us briefly consider each.

State forestry may be said to concern itself with tree restoration and removal on soil which belongs to the State, or on soil which it is for the general interest that the State should control. Properly conducted, State forestry should consider ultimate consequences, and shape a perpetual policy which should extend forward indefinitely. It considers measures in the light of State perpetuity. It raises and solves the question as to what will be the ultimate effect on the proper conservation of water in the soil. How will stream beds be affected if this or that body of timber is destroyed, and what kind of timber can be grown most advantageously to the Commonwealth on any given area? Individual interests are, by it, wholly submerged in the general consideration: what will longest preserve and most benefit the community?

Of course, it is an open secret that State forestry has hitherto flourished most under the protection of a monarchical government. Perhaps it always will. With the recurring cries of "turn the rascals out," marking the change from one administration to another, it would be folly to expect a permanent policy, which could calmly contemplate any plan looking into the next century for its completion, however worthy that plan might be. The temptation to meddlesome interference is too great to be successfully resisted.

It follows, then, that the next best plan must be substituted for a general system of State forestry, and the latter appealed to only when it must be.

We believe that the highest function of the State is to allow every man the fullest chance to work out the best that is in him. Greater help than this becomes a doting paternalism, and is more likely to weaken than to strengthen the recipient. Now, to apply this principle, what is required? First, that each person should know how to act. Our public school system has this idea for its basis. It is more a public than a private benefit that we should know how to stamp out contagious disease, or to utilize present resources so as not to entail want upon the children we have begotten. In rational treatment of our forests, as a people, we are wholly

ignorant, and this public admission for the mass of the people is good for the national soul. But we are not hopelessly stupid. On the contrary, no people pick up a new idea with greater avidity, or comprehend it more promptly, if the moving motive is properly appealed to. To convey this instruction the State should own forest reservations where approved methods of tree culture could be illustrated, and where, at the same time, the State could have under its own absolute control such areas, as, if allowed to remain the property of the individual, would become a menace to the peace and prosperity of the community, by the frequent unrestricted deluges which would pour down from the steep and naked slopes. Ignorance of forestry to-day will cost this Commonwealth not less than $37,000,000 annually, in the near future, and will leave us with a great gap in the list of our most productive industries.

Furthermore, individual forestry should be encouraged, because the surface of the State must, to a certain extent, be covered with trees. The interest of the people demands their *presence*, as well as their *products*. It is merely a question whether the State shall, at a great cost, imperfectly preserve this equilibrium, or make it the interest of the individual to accomplish the same result for it, not only cheaper, but better. We may lay down the general proposition that a tree pays the State, in instant benefit, for the privilege of growing, every hour that it stands. Yet with this incontestable truth in plain view, our laws are actually placing a premium upon a system of forest destruction, which is as unnecessary as it is wasteful. As things now are, there is practically a prohibitory tax upon maintaining tracts of timber, which the future will need vastly more than we do. Or to put the facts in another shape, we may say that there are vast areas of woodland in this State which, in the last thirty years, have been confiscated by taxes, because these have aggregated more than the land can be sold for to-day. To make matters worse, during all this time, in spite of taxes being paid, the owner has received for the same property no protection whatever. The very same county commissioners who expend his money

refuse to accord the protection against forest fires which the law makes it their specific duty to furnish.

The time will come, and can come none too quickly, when not only will this gross injustice be abated, but when the true relation of the forests will be so plainly recognized that the individual will find the State encouragement which he needs to enable him to serve himself in serving the community.

INTERSTITIAL SPACE.

By T. Dunkin Paret.

London *Engineering*, for February 22, 1895, contains an abstract of a paper by Mr. Spencer R. Newberry read before the Ohio State Engineers' Society. This paper refers to the manufacturing of concrete. The abstract begins by stating that "it is well known that the voids in a mass of particles, all of nearly uniform size, are greater than when the dimensions of the particles vary largely, and hence in cement testing, the voids in standard sand, carefully ground to be uniform as possible, are much greater than in ordinary gravel." The abstract then states that "in making a concrete the materials should be mixed so as to fill the voids as full as possible, the amount of cement required for this being increased by ten to fifteen per cent. for safety." It also says "that a suitable addition of gravel to sand may strengthen the concrete," and gives a tabulation showing various proportions of cement, sand and gravel, with the crushing strength in pounds per square inch duly tabulated.

While this abstract may do injustice to Mr. Newberry's paper, its general effect is that produced by nearly all formulæ for the manufacture of concrete and by all articles in reference to such manufacture. In other words, there are certain facts and figures given, which are definite and specific, and a general vagueness in reference to that secret of quality which really lies (the cement being assumed as

always of equal quality) in *the proportioning of the filling to the interstitial space.*

If an absolute rule could be discovered by which proper proportions could, in all cases, be arrived at, such a rule ought to be of inestimable value, not alone in its relation to the manufacture of concrete, but also in reference to the proportioning of very many mixtures. Certain facts leading to the establishment of such a rule are to be found in a series of investigations concerning the manufacture of solid emery wheels, which investigations had their origin in a rather peculiar manner.

In an attempt to establish the varying qualities of different kinds of emery by the manufacture of these kinds into solid wheels, and by subsequent scientific tests, certain startling discrepancies were discovered. A number of wheels made by exactly the same formula were found to differ greatly, and various facts indicated at once and unquestionably that the difference was not due to the intrinsic quality of the emery. The question was then carefully considered as to how exactness of formula could be arrived at; for it is evident that, in a mineral like emery, amounts of equal quantity by weight might differ considerably in volume. Further investigation made that fact apparent, which, indeed, seems evident on theory, that, in order that the mixture should be of the same formula, exact bulks ought to be taken, rather than exact weights. Wheels being made of different emery by the same formula, equal bulks of emery being taken, differences in quality were again discovered, clearly not due to the difference in the quality of the ore. The suspicion then arose that this difference was due to the amount of interstitial space, the theory being that there was more space in some cases than in others, and that, where there was less space, there was an excess of that material which was used to bind and fill. To settle this fact, a prolonged series of experiments was made, whose course was as follows: An accurately fitted cubic inch cell of planed cast iron was made, and this cell filled with emery. Three trials were made with each kind of emery. At each filling of the cell an equal number of taps was given with a mallet upon

a wooden rammer, and the cubic inch mass was carefully levelled at the top. A medicine dropper, after having been tested as to its uniformity of drop, was employed to fill the interstices between the emery with water. Three trials were made in each case, and it was at once discovered that while one brand of emery only required 136 drops to fill it, another kind required 152. As doubt might still exist as to whether the absorptive capacity depended entirely on the interstitial space or upon some possible porousness of the mineral (although emery is supposed to be practically impervious to water) the attempt was made to demonstrate whether the variation was due to porous absorption or to the variation of interstitial space. This was settled by taking grains of that quality which only took up 136 drops, and so treating them that the angular corners were worn off and the grains rounded. It was then found that they took up 155 drops.

In these facts there is nothing startling or new, it being well known that a mass of perfect spheres of one diameter would have more interstitial space than a mass of atoms of irregular sizes and shapes, whose flattened sides and angular points would so arrange themselves under pressure as to come in the closest contact and leave the least amount of interstitial space. But, while there is nothing new in the general result, it may be that no exact data are to be found of the same character as those now offered, and from which deductions can so safely be made. We furnish herewith a tabulation showing the numbers of minims of water required to fill the interstices in one cubic inch of emery, giving the weight of the cubic inch in each case, and the percentage by weight of water required to fill the interstices.

Name of Emery.	Number of Emery.	Minima of Water Required to Fill Interstices in 1 Cubic Inch Emery.	Weight of 1 Cubic Inch of Emery in Grains.	Per Cent. of Water by Weight Required to Fill Interstices in 1 Cubic Inch Emery.
Tanite Mills Emery	6 UC	131	545	14·85
" "	10	133	542	14·30
" "	14	137	539	14·75
" "	18	139	533	14·99
" "	24	140	530	15·20
" "	36	140	526	15·32
" "	54	141	522	15·51
" "	80	147	522	16·07
" "	100	153	512	16·88
" "	140	160	504	17·80
" "	180	164	502	18·17
" "	200	164	502	18·17
" "	Ex.			
" "	R. F.	180	427	22·27
Average		148	516	16·32
Equal parts by weight of the above thirteen sizes		95	675	8·73
Tanite Mills Emery	20 UC	136	532	14·64
Wellington Mills Emery	20	149	531	16·02
Washington Mills Emery	20	152	529	16·34
Tanite Mills Emery	20 UCR	155	532	16·53

The emery used in above tabulation is numbered to correspond with the mesh of the wire cloth on which it was made; but as commercial emery answering to these numbers varies considerably in size, all of that which was used in these experiments was carefully sifted by hand on the same sieves.

The regularity of the progression in each series of numbers is remarkable from the fact that the experiments were not made in consecutive order, as tabulated, but the different numbers were taken entirely at random at different times covering several weeks. Three trials were made with each number of emery, the mould being first filled half full of emery, and then receiving ten light blows upon a wooden plunger, then filled level and receiving ten more light blows, then filled heaping and receiving five blows, then finally levelled and filled with water from the dropper. *The facts indicate clearly that the interstitial space does not depend entirely upon uniformity of size, but is governed largely by diversity of shape.*

The tabulation given in *Engineering*, and those generally given in reference to the manufacture of concrete, which

roughly state so many parts of cement, so many parts of sand, and so many of gravel, seem to us vague in the extreme; and it would appear that a process, analogous to that used in arriving at the interstitial space of emery, might be used easily, cheaply, practically, and with great effect, in the manufacture of concretes and other mixtures. Where concretes are made in quantity, stone crushers and sifting machines are commonly used. It would be an easy thing in every such case to have a cubic foot cell in which crushed stone (of the average size actually being produced by the stone crusher and sifter then in use), was filled, and the interstitial space of that very stone arrived at by the use of water or other fluid. In like manner both sand and gravel could be so sifted that the average size of each was ascertained, and the sand be used as a partial filler for the interstitial space of the gravel. While the crushing strength of concrete is no doubt largely affected by the cleanness, roughness and angularity of the freshly-crushed stone surfaces, and by the areas of the lime and silica which come in contact, it, nevertheless, seems evident that the crushing strength would be greatly modified by the amount of filling between the stone being so carefully proportioned to the interstitial space that, when that coarse stone was compressed to its utmost extent, the irregular space would be completely filled, while the faces of the stone which came nearest in contact had only a slight layer of filling between them.

In the subjoined table will be found a few facts concerning the interstitial space in crushed stone. To obtain the result shown in this brief tabulation, a rectangular box with a capacity of one cubic foot was used, which box was filled as nearly level as possible with stone and then weighed, the interstices filled with water, and the whole weighed the second time.

Name of Material.	Approximate Size in Inches.	Weight of 1 Cubic Foot of the Material.	Water Required to Fill Interstices Contained in 1 Cubic Foot of Material, Pounds.	Per Cent. of Water by Weight Required to Fill Interstices Contained in 1 Cubic Foot of Material.
Broken Ore (Emery)	3½ × 3½ × 2¾	126	29¼	18·83
" "	3¼ × 2¼ × 1¾	116	32¼	21·75
" "	2 × 1¾ × ¾	121¾	31	20·36
Rounded Stone (from creek)	2¾ × 1½ × 2¾	95	27	22·13

On theory, it might have been imagined that the rounded stone would, as has been suggested for exact spheres, contain more interstitial space than the crushed ore, but the crushed material was so irregular that it formed bridges, and, unlike the fine emery grain and unlike the stone pounded down in cement and sand, it could not bed itself or become more compact, but remained in the loose position in which it was thrown. The facts which appear most striking in these investigations are a very regular increase of space and diminution in weight of emery grain, as this latter increases in fineness—and the increase of 12·91 per cent. of space due to the mere change of shape in the Tanite Mills emery marked respectively UC and UCR, and the very remarkable decrease in space and increase in weight where thirteen sizes were combined in one cubic inch. The facts here given are not presented as affording an adequate explanation of how a perfect cement can be made, but are rather intended to suggest to other investigators practically interested in the subject a method by which exact results can easily and cheaply be secured.

THE FRANKLIN INSTITUTE.

Stated Meeting of May 15, 1895.

MR. H. R. HEVL, Vice-President, in the Chair.

[The Chairman announced the paper of the evening, and introduced the speaker.]

THE BALL NOZZLE.

BY ARTHUR KITSON.

Among the multitude of inventions which, year by year, find their way to the patent office, none attract more attention than those inventions which appear to be of the nature of a paradox, and which the newspapers are fond of describing as "scientific puzzles."

Such inventions as the injector, by means of which water is forced into a steam boiler by the same pressure of steam as that contained in the boiler itself; the down-draft furnace, in which the air for combustion is supplied at the top of the fire instead of at the bottom; the system of heating rooms, by placing the hot-water pipes on the ceiling instead of on the floor—all such inventions which operate on the reverse plan to that with which we are accustomed, at first sight strike us as contrary to the natural order of things, and there is a tendency amongst a certain class to consider the phenomena as marvelous.

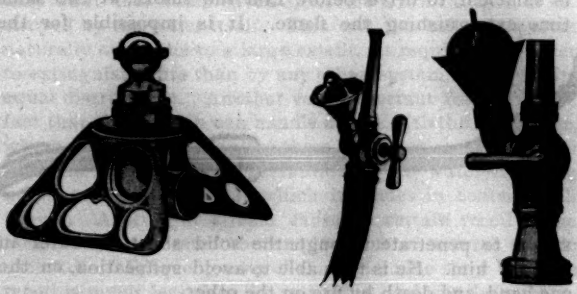
Of the very recent inventions that have in this way excited a great deal of discussion, what is known as the "ball nozzle" is probably the most widely advertised, and the principle governing it the least understood. Because in its operation it presents a phenomenon hitherto unobserved, it has been characterised by the press as contrary to the laws of science. There is, however, nothing of the miraculous or of the supernatural which cannot be explained by well-known scientific principles.

The "ball nozzle" is one of the simplest inventions ever designed. It consists merely of two parts: a bell-shaped or flaring-mouth nozzle, and a ball. The nozzle is connected

to a water or air supply, and the ball is placed loosely in the mouth of the nozzle. The ball steadfastly adheres to the nozzle and refuses to leave it, notwithstanding the great pressure of the issuing stream of air or water, and no matter what may be the position of the nozzle, whether vertical or horizontal, or whether the nozzle be turned directly towards the ground. As soon as the pressure is released and the supply of water ceases, the ball, obeying the law of gravity, falls. Variations of pressure from a few ounces to hundreds of pounds to the square inch fail to change the nature of the seeming paradox. In the case of water, the effect of the ball is to divide what would otherwise be a straight stream into a thin, fan-shaped spray, which spreads itself in a circle all around the nozzle. It is in this respect that its

utility arises. One of the essentials of a good water spray for agricultural purposes, or for lawn sprinkling, is the equal distribution of the water, so that an even supply can be furnished without much expenditure of energy. In this field the ball nozzle furnishes an almost perfect machine and seems to be the only genuine "rain-maker" now placed upon the market. With a pressure of 80 pounds to the square inch and a $\frac{3}{16}$ orifice, it is possible to distribute a water supply over a circular area 60 feet in diameter. Such a machine is a convenience and a labor-saving invention which only those who have been accustomed to the old-fashioned lawn-sprinklers can properly appreciate. As a method of distributing fresh air to railway cars or rooms, this invention also seems to fill an important function. But

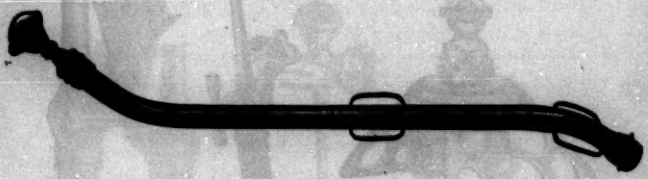
its most useful field, and one in which it comes as a blessing to humanity, is that of a fire-extinguisher. It is one of the glories of science and of invention that, whilst the progress of the human mind in the realm of discovery often brings increased danger to human life, accompanying it—like a guardian angel—are those inventions which act as safe-guards to protect life from those dangers to which inventions have given rise. With the ever-increasing dangers which increased speed of ocean travel has occasioned there have likewise arisen increased means and facilities for saving life. The danger attending the use of elevators brought forth the safety catch; and rapid transit, furnished by the trolley system, is soon to be accompanied with the fender,



which will make it almost impossible to sacrifice life in the accomplishment of so desirable an object.

Fire is at once man's preserver and his destroyer, and few things indispensable to him have proved so destructive of life and property as this element. It is estimated that, during the past twenty years, not less than 250,000 lives have been lost, and over $200,000,000 of property destroyed by fire in this country alone. An invention that will in any way mitigate or lessen this awful destruction of life and property must be hailed as one of the greatest benefits that the mind can confer upon society. It is in this field that the ball nozzle will serve its highest function. The large nozzles displayed here to-night are designed for this particular pur-

pose. You will see the end of the fire nozzle has two openings—one consisting of a straight orifice, from which a solid thick stream may be directed, as in the ordinary fire nozzle, and the other consisting of the ball nozzle. A three-way valve serves to direct the water to either of the openings. The *modus operandi* is as follows: A fireman, on reaching a building in which a fire is raging, first directs the straight stream against a window of the building in order to reach the fire with the spray. He then turns his valve and admits the water to the ball nozzle and directs it toward the fire. On entering the building he can proceed at once to meet the fire by placing the nozzle in front of him. He then becomes enveloped with a sheet of water, the force of which is sufficient to drive before him the smoke, at the same time extinguishing the flame. It is impossible for the



smoke to penetrate through the solid sheet of water in front of him. He is thus able to avoid suffocation, on the one hand, and death by fire on the other.

Those who have witnessed large fires and have studied the action of the ordinary fireman's hose, must have been surprised with the apparently slight effect which the water has had upon the fire. The reason is that the whole stream and force of water is directed upon a very small space, not many times larger than the orifice through which the water escapes. To overcome this defect it becomes necessary for the fireman to keep the nozzle moving so as to distribute the water. The result, however, is not satisfactory. Certain parts of the fire get more water than is sufficient to extinguish the flame, and other portions do not get any. Moreover, whilst the water is directed on one small area, the fire is making headway in other portions of the build-

ing. It must have occurred to many a man, especially firemen, that if the force could be immediately distributed from one source of supply, sufficient to cover the whole or a large part of a building, that fires could be much more rapidly extinguished and with less danger and loss. This is precisely what the ball nozzle does. Instead of concentrating large volumes of water upon a small area, the nozzle distributes it evenly over large areas, so that all parts of a room or side of a building can be treated equally to the fire-extinguishing element. It is estimated that fifty per cent. of the damage and loss occasioned from fires arises from the excessive use of water. This must be so from the ordinary fire apparatus, and it generally happens that what the water saves from the fire's ravages, is destroyed by the water itself. This evil the ball nozzle must naturally overcome to a large extent. It requires less water to extinguish a fire than by any other system, owing to its equal distribution. Another very important feature is the fact that one fireman can handle a hose with the ball nozzle, where ordinarily it requires three or four men. This seems to be the result of the distribution of the water from the nozzle and the manner in which it comes in contact with the air. A straight stream causes a certain recoil of the hose and necessitates the employment of several men to each hose. Frequent tests of the ball nozzle show that this recoil is much less than in any other, and can be successfully resisted by one man.

In this respect its utility is found to be most valuable.

I refer you to the circulars that have been placed in this hall, containing the endorsement of the various insurance companies and underwriters throughout this country. No institutions are more particular or more conservative about endorsing fire-extinguishing devices than insurance companies, and yet to none are such devices of more importance. Not less than 130 of these companies have endorsed this invention as an improved fire appliance. Judging from the numerous accidents that have occurred recently in private houses from defective flues and exploding lamps, it appears essential that some appliance for extinguishing

fire should be provided in every home, and it seems to me that by the aid of this invention the problem may be solved. From twenty-five to fifty feet of hose, attached at one end to the water supply, and fitted at the other with a ball nozzle, may be placed in every bath-room and kitchen, and, in the majority of cases, would serve to extinguish fires in private houses before much damage had occurred.

I have briefly described this invention and its most useful applications and have left the explanation of the phenomenon for final discussion. The problem connected with this invention may be put thus: Why does the ball adhere to the nozzle when there is behind it a force aggregating as high as hundreds of pounds pressure? The explanation usually given is that the atmospheric pressure holds the ball in its place and prevents it from falling or leaving the mouth of the nozzle. To this others answer that the pressure behind the ball far exceeds the atmospheric pressure; for instance, there is an exhibition given daily in New York with one of these nozzles where the water pressure equals 100 pounds per square inch, and as the atmospheric pressure is only about fifteen pounds, it would at first sight seem that the excess of pressure on the under side of the ball was eighty-five pounds, and ought, therefore, to expel the ball. The error, however, in this argument arises from failure to distinguish between the pressure of the water when confined in the pipes and when issuing around the ball. It is very certain that if 100 pounds pressure were acting directly upon the ball, it would be blown out of the nozzle, but it does not appear to me to act in this way. When the ball is confined to the mouth of the nozzle and pressed against it, it is undoubtedly subjected to the pressure of the water, but the moment it is raised slightly from the mouth, it is no longer subjected to this pressure, since the water is escaping all around it. In this respect it resembles the lid of a tea kettle when the water is boiling. By plugging the spout, the lid will be raised by the steam pressure sufficiently to allow the steam to escape at the sides. The explanation that seems to me

to be the correct one is as follows: The ball is acted upon by three forces: first, gravity; second, atmospheric pressure; and third, the force of the issuing stream. At first, the atmospheric pressure is the same at all points, and hence gravity has free play; but as soon as the stream passes through the nozzle, the atmospheric pressure from the under side is counteracted by the momentum of the issuing water, and the ball rising to a point where the water can pass freely around the sides, without pressing materially upon the ball, we have the full pressure of the atmosphere on the under half-side of the ball resisting the force of gravity. The ball, therefore, simply serves as a deflector to divert the current of water or to spread it out, and the resistance of the atmosphere against the ball suffices not only to perform this operation but also to sustain its weight.

It is possible that the density of the air may also be somewhat increased under the ball by the action of the spray. With a heavy pressure, the ball is further removed from the nozzle than with a light pressure. The same holds good respecting a heavy ball and a light ball. Most of these so-called paradoxes may be attributed to momentum or inertia. Take, for instance, the phenomenon of the injector. "If a 1-inch opening in a boiler, carrying 15 pounds pressure above the atmosphere, be made, if there is no reduction by friction, steam will issue from it at a velocity of about 1,440 feet per second, and the steam which would issue from it would be 10 cubic feet per second, which would weigh $\frac{1}{2}$ of a pound. When this steam is condensed to water, it maintains its velocity but is reduced in volume from 10 cubic feet to $\frac{1}{900}$ of a foot, or in other words, the stream of steam of 1-inch area, which issued at 1,440 feet per second, is reduced to a stream of water $\frac{1}{32}$ of an inch in diameter, having the same velocity—1,440 feet per second.

"The laws of hydraulics show that water will issue from a vessel under a pressure of fifteen pounds per square inch, with a velocity of forty-five feet per second, and that any stream having a greater velocity than forty-five feet per second, if directed against the orifice in the vessel, will enter it, notwithstanding the pressure inside the vessel.

The jet of condensed steam has a velocity of 1,440 feet per second, or more than thirty times that necessary to re-enter the boiler. This velocity is, therefore, reduced by mixing it with 900 times its weight in water, and this mixture will still enter the boiler."* This, of course, is merely theoretical and is largely reduced by friction; but in practice it is well known that steam will carry many times its own weight in water into a boiler from whence the steam is itself derived. We have, therefore, in the ball nozzle, the momentum of the moving stream of water which overcomes the atmospheric pressure on the under side of the ball, and the inertia of the ball which serves to keep it from moving, aided by the atmospheric pressure on its top side. This is my own explanation of a phenomenon which seems to puzzle a great many people, but which is strictly soluble by the well-known laws of physics.

In conclusion, I believe this invention, simple as it is, is destined to become a very great friend of society, particularly as a protection against the scourge and devastation of fire, and a means of saving human lives as well as very much of the wealth which annually disappears in smoke.

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HAVING THE LOGARITHMS OF TWO NUMBERS, TO FIND THE LOGARITHM OF THEIR SUM OR DIFFERENCE.

By Nathaniel Hill.

For the solution of this problem, *addition* and *subtraction* logarithms were devised; Zech's seven-figure tables being published in the year 1849, and the five-figure tables of Gauss presumably quite as early, as his name is often used to identify this kind of logarithm. Newcomb's five-figure tables, Pierce's, Wheeler's and Macfarlane's four-figure tables are more recent, and are also American publications.

* Appleton's Cyclopædia.

Newcomb aptly says of these tables: "The problem can, of course, be solved by finding the numbers corresponding to the logarithms, adding or subtracting them, and taking out the logarithm of their sum or difference. The table under consideration enables the result to be obtained by an abbreviated process."

It is proposed here to show methods of solving the problem without other than the common logarithmic tables, which will compare favorably with the method by special tables, in respect of abbreviation, convenience and precision.

The use of seven-figure tables will first be explained: Take the difference of two given logarithms as the argument, and when this argument is 6·+, 5·+, or 4·+, take, respectively, the $\frac{1}{100}$ part, the $\frac{1}{10}$ part, or the whole tabled difference belonging to the tabled logarithm nearest to the argument, which add to the larger given logarithm for the logarithm of the sum, or subtract the same for the logarithm of the difference.

When the argument is 3·+, or 2·+, and the logarithm of the sum is required, take the difference between the tabled logarithm nearest to argument, and that logarithm, one line or ten lines below, and add to larger given logarithm; for the logarithm of the difference, take the difference between the nearest tabled logarithm and that, respectively, one line or ten lines above, and subtract from the larger given logarithm.

The principle involved cannot be applied to the remaining cases; that is, when argument is 1·+, or 0·+. The method applicable to these cases will be explained after the above *special method* is exemplified.

EXAMPLES.

1st Argument = (diff. (1) and (2).) . .	(3)	6·2439554	
Given	(1)	7·8798411	
"	(2)	1·6358857	
Tabled diff., 248·	(4)	2	
Add (4) and (1)	(5)	7·8798413	= *log. of sum.*
Sub. (4) from (1)	(5)	7·8798409	= *log. of diff.*

2d Argument = (diff. (1) and (2).)	(3)	5·2439554
Given	(1)	6·8798411
"	(2)	1·6358857
Tabled diff., 248·	(4)	25
Add (4) and (1)	(5)	6·8798436 = *log. of sum.*
Sub. (4) from (1)	(5)	6·8798386 = *log. of diff.*

3d Argument	(3)	4·2439554
Given	(1)	5·8798411
"	(2)	1·6358857
Tabled diff.	(4)	248
Add (4) and (1)	(5)	5·8798659 = *log. of sum.*
Sub. (4) from (1)	(5)	5·8798163 = *log. of diff.*

4th Argument	(3)	3·2439554	Nearest tabled log. ·2439553
Given	(1)	4·8798411	Log. on line below ·2442029
"	(2)	1·6358857	Diff. (4) 2476
	(4)	2476	
Add (4) and (1)	(5)	4·8800887 = *log. of sum.*	
	(1)	4·8798411	Log. nearest arg. ·2439553
	(4)	2477	Log. on line above ·2437076
			Diff. (4) 2477
Sub. (4) from (1)	(5)	4·8795934 = *log. of diff.*	

5th Argument	(3)	2·2439554	Nearest tabled log. ·2439553
Given	(1)	3·8798411	Log. 10 lines below ·2464247
"	(2)	1·6358857	Diff. (4) 24694
	(4)	24694	
Add (4) and (1)	(5)	3·8823105 = *log. of sum.*	
	(1)	3·8798411	Log. nearest arg. ·2439553
	(4)	24835	Log. 10 lines above ·2414718
			Diff. (4) 24835
		3·8773576 = *log. of diff.*	

A general method, applicable to all cases in all tables of logarithms, not as convenient, however, as that shown for the cases already given, now follows, and is to be used for arguments 1· + and 0· +, and sometimes, for argument 2· +.

Enter table with the difference of the given logarithms, and observe the number corresponding to argument, and, for the logarithm of the sum, take out the logarithm of a number one unit larger and add to the smaller given logarithm; for the logarithm of the difference, take out the

logarithm of a number one unit smaller and add to the smaller given logarithm.

6th Argument	(3)	2·2439554 = log.		175·37004
Given	(1)	3·8798411	Add . .	1
"	(2)	1·6358857		
Log. 176·37004	(4)	2·2464248		176·37004
Add (4) and (2)	(5)	3·8823105 = *log. of sum.*		
				175·37004
			Sub. . . .	1
				174·37004
	(2)	1·6358857		
Log. 174·37004	(4)	2·2414719		
Add (4) and (2)	(5)	3·8773576 = *log. of diff.*		
7th Argument	(3)	1·2439554 = log.		17·537004
Given	(1)	2·8798411	Add . . .	1
"	(2)	1·6358857		
Log. 18·537004	(4)	1·2680395		18·537004
Add (4) and (2)	(5)	2·9039252 = *log. of sum.*		
	(2)	1·6358857		
Log. 16·537004	(4)	1·2184568		
Add (4) and (2)	(5)	2·8543425 = *log. of diff.*		
8th Argument	(3)	·2439554 = log.		1·7537004
Given	(1)	1·8798411		
"	(2)	1·6358857		
Log. 2·7537004	(4)	·4399167		
	(5)	2·0758024 = *log. of sum.*		

It may be noted of the above cases that the second reference is conveniently made from the first; that is to say,

with argument 0· +, at same place on page 10, leaves forward or back.
" 1· +, " " " 1 leaf " "
" 2· +, " column 10 lines " "
" 3· +, " " 1 line " "
" 4· +, at adjoining logarithms.
" 5· +, and above, to same logarithm and proportional parts.

Two cases showing irregularity in the second reference are shown below:

Argument ·302—, and logarithm of difference required:

9th Argument	(3)	·2439554 = log.		1·7537004
	(1)	1·8798411	Sub. . . .	1
	(2)	1·6358857		·7537004
Log. ·7537004	(4)	9·8871957		
		1·5130844 = *log. of diff.*		

Argument more than ·954, and logarithm of sum required.

10th Argument	(3)	·9639554 = log.		9·20355
	(1)	1·8798411	Add . .	1
	(2)	·9158857		10·20355
Log. 10·20355	(4)	1·0087512		
	(5)	1·9246369 = *log. of sum.*		

The methods shown for arguments 2·+, and larger, apply to five, and four-figure tables, in the order following:

Seven-figure Tables.	*Five-figure Tables.*	*Four-figure Tables.*
That for Arg. 6·+	to Arg. 5·+	
" 5·+	" " 4·+	to Arg. 3·+
" 4·+	" " 3·+	" " 2·+
" 3·+	" " 2·+	" " 1·+
" 2·+	" " 1·+	

The methods for arguments larger than 2·, in seven-figure tables, and 1·, in five, and four-figure tables, may be expressed by this *special rule:*

Enter table with the difference of given logarithms, and, for logarithm of the sum, observe the difference between the tabled logarithm nearest to argument, and that of a number one unit greater than the number corresponding to the nearest tabled logarithm, and add this difference to greater given logarithm; for logarithm of difference, subtract the difference between the nearest tabled logarithm and that of a number one unit smaller, from the greater given logarithm.

The foundation of the general rule is

$$log.\,(a \pm b) = log.\,b\left(\frac{a}{b} \pm 1,\right)$$

and that of the special rule is

$$log.\, b\left(\frac{a}{b}+1\right) = log.\, a + log.\left(\frac{a}{b}+1\right) - log.\,\frac{a}{b},$$

and

$$log.\, b\left(\frac{a}{b}-1\right) = log.\, a - \left(log.\,\frac{a}{b} - log.\,(\frac{a}{b}-1)\right)$$

In all cases, $a > b$.

The application of these or other formulas to the solution of the stated problem, by means of the common logarithmic tables, is believed to be now for the first time presented.

LOWELL, MASS., June 1, 1895.

ELECTRICAL SECTION.

Stated Meeting of May 28, 1895.

MR. CARL HERING, President, in the Chair.

TEST OF AN ELECTRIC RAILWAY.

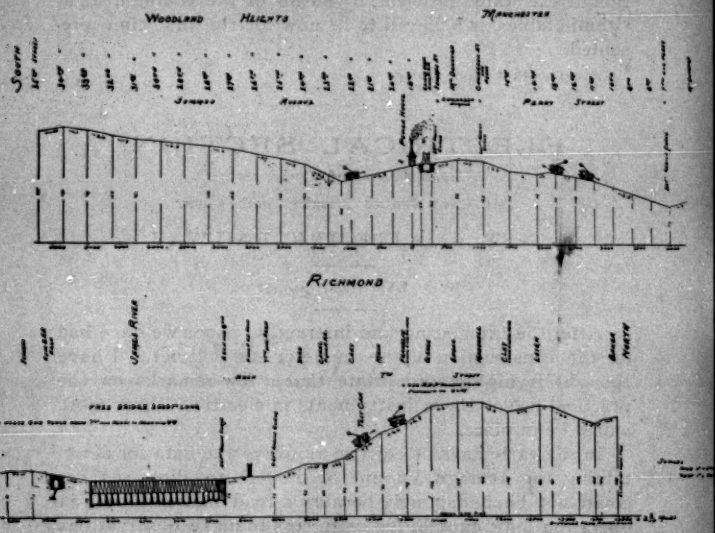
BY A. LANGSTAFF JOHNSTON.

After the interesting and instructive paper we have had on the construction of the ammeter and voltmeter, I have thought it highly appropriate that a few remarks on the practical use of these instruments in electric railway work would be in place.

In the early days of electric railways the data for determining the average amount of current to allow per car could not be had, simply because a road had not been in operation long enough for engineers to make observations on this point.

In 1890 I constructed a line which, for alignment, grades and local conditions, can be classed as a "difficult route," curves 30 feet radius on grades and in narrow streets, grades $7\frac{4}{10}$ per cent., and running over other roads. As the road was operated by one Edison 80 kilowatts generator, driven by one 100 horse-power Ball engine, the equipment consisted of five cars mounted with two 15 horse-power Sprague motors each; all these conditions made it highly favorable

for giving results of practical value. I made a series of tests, not only to determine this point, but the total amount of current leaving the power-house, when the cars were in the most unfavorable combination, *i. e.*, the majority ascending the grades. Although not as extensive and as accurate as I wished, yet I have considered them of sufficient interest to present to you. To accomplish this, on one of the cars



Profile of the Richmond and Southside Electric Railway, showing location of cars when test car No. 5 on maximum grade, by A. Langstaff Johnston, M. Am. Soc. C.E. Nov. 1, 1890.

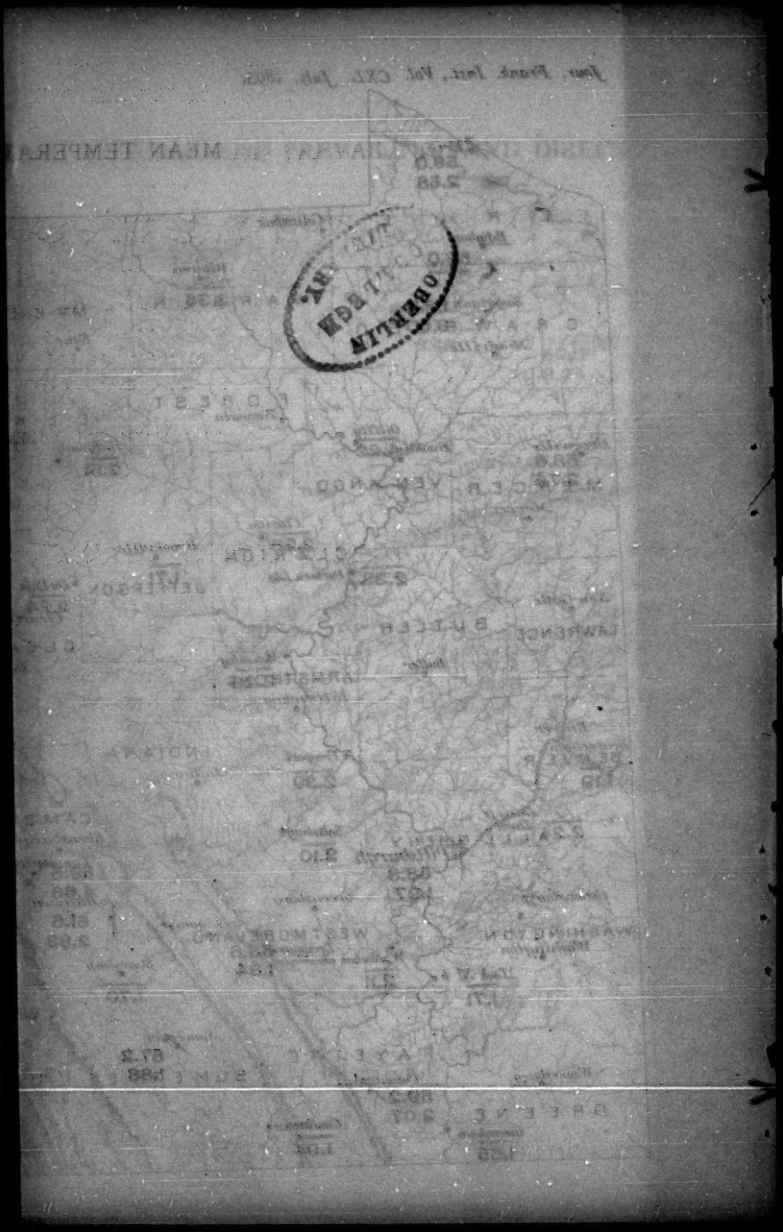
was placed a Weston portable ammeter and voltmeter, on the other four cars were placed observers with time cards upon which they noted the time of passing previously marked points on the line, all watches being set with the clock at the power-house, where an observer took the reading of the station instruments.

The profile and table which you now have on the screen,

give the general data of one of the tests, and one when the test car was going over the road from the south to the north. The profile shows the location of the other four cars at the very instant the test car was on the centre of the maximum grade ($7\frac{4}{10}$ per cent.), and the table, the data taken on the car and in the power-house during the test.

A study of the table brings out some very interesting points—(1) The maximum amount of current (100 ampères) was at 6·05 P.M., when the test car was on a level and 6,500 feet from the power-house, and using the minimum amount of current (10 ampères). This was caused by the position of the other four cars, the time cards of the observers showing them either on the heavy grades or on the curves. (2) At 5.53 P.M., the test car used the maximum amount of current, and was also on a level and only 300 feet from the power-house; as should be expected, there was no drop in the voltage. It is also seen that the test car, in passing around the curves at Seventh and Perry Streets, Ninth and Arch Streets and Seventh and Arch Streets, took the same amount of current, but with a very large drop in the voltage (80 volts) at Seventh and Arch Streets. At first it was hard to explain this, but by a study of local conditions at this point, I discovered that the motorman had to shut off the current, and did not turn it on until he was in the centre of the curve, when he had to open it up to the seventh notch of the controller to force the car around this 40 feet radius curve, which readily accounts for the large drop that is shown. The same explanation applies to the curve at the Semmes Avenue Bridge; there the car had to cross a narrow bridge at a low speed, on a curve of 35 feet radius. (3) On the maximum grade of $7\frac{4}{10}$ per cent., which was 9,800 feet from the power-house, it took 40 ampères and 440 volts (which was forty volts drop on the line), or $23\frac{1}{2}$ electrical horse-power, to take the test car up the grade at the rate of four miles an hour. The profile shows the test car on this grade, and the location and the direction of travel of the other four cars at this very instant.

These tests show very conclusively the electrical economy that can be gained by a continuous-running motor, which



JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXL. AUGUST, 1895. No. 2

THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal.*

THE PNEUMATIC FIRE-ALARM TELEGRAPH SYSTEM.

[*Being the report of the Franklin Institute through its Committee on Science and the Arts, on the invention of Albert Goldstein.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1895.

The Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating Goldstein's Fire-Alarm Telegraph System, reports as follows:

This device is entirely pneumatic and mechanical within the building protected, and embodies a magneto-electric machine for the transmission of the telegraphic alarm to the fire-department headquarters, and which is covered by the following patents:

Nos. 213,536; 242,803; 253,133; 446,863; 455,038; 479,909; dated respectively, March 25, 1879; June 14, 1881; January 31, 1882; February 24, 1891; June 30, 1891; July 26, 1892.

The system consists essentially of three parts, viz.: A thermostat, which acts under the influence of the heat of a fire near it; an annunciator, which receives the alarm from the detector or thermostat, and indicates it by visual room or floor signal and the ringing of a mechanical bell; and a transmitter, which is also actuated by the thermostat, and transmits the alarm by wire to a predetermined station; all these connected by closed pipes within the building.

The thermostat consists of a cylinder in which is a washer of asbestos coated with paraffine, and beneath the washer a loose-fitting piston, which receives the pressure of a spiral steel spring (piano wire), which spring is held under compression by a rod, the lower end of which is retained by two halves of a disk, which are held together by a solder which melts at a temperature of 150°.

When the thermostat is subjected to this temperature, the two halves of this disk part, releasing the rod and the spring, which, by its upward thrust on the piston and washer, with a quick impulse, drives the air in the cylinder through the pipe, producing a corresponding impulse upon a small bellows or diaphragm in the receiver. There may be many of these thermostats on the same floor pipe, and the pressure of an alarm is prevented from being expended in them by check valves, which yield to pressure from within but resist it from without the cylinders. The washer, saturated with paraffine, and fitting tightly in the cylinder, is hermetically sealed to it by the paraffine being melted around its edges, and is absolutely air-tight in its upward motion, in which it is facilitated by the softening of the paraffine from the heat to which the cylinder is subjected externally.

The pipes from each room or floor respectively, carrying a sufficient number of thermostats, are grouped together where they reach the annunciator, and the latter is connected by one pipe to the transmitter.

The annunciator contains a clockwork, adapted when released to ring a mechanical gong; a number of shutters, adapted when dropped to designate rooms or floors in the building; and a number of bellows connected to the respective pipes, adapted when actuated by an impulse of air from

a detector to drop the proper shutter and release the clockwork, thus ringing the local alarm and visually indicating the location of the fire. This local alarm runs for nearly fifteen minutes, and is for the purpose of alarming the occupants if present, and also for calling attention of the firemen, when they respond, to the annunciator, which indicates the particular location of the fire. For that purpose it is located preferably just within the main entrance of the building.

The transmitter consists essentially of a magneto-electric machine, impelled by a weight, which is released by an impulse of air from any thermostat in the building, and is electrically connected by wire with the central exchange of the local telephone company.

A wheel geared to the armature of this machine is furnished with contact springs, by which the number of the machine is telegraphically indicated in the usual way.

Thus, when any thermostat in a building protected by this apparatus is raised to a temperature of 150°, the fusible solder is melted, its spring is released, and its paraffined washer is driven up, sending an impulse of air to the annunciator and transmitter simultaneously; the former rings a bell, showing that there is a fire in the building, and drops a shutter showing the room or floor in which the fire exists. The shutter remains dropped until the firemen come, and at the same time the transmitter sends an alarm to the fire department headquarters, calling out the fire department and telegraphically indicating the building.

The transmitter is connected preferably to the existing telephone wire in the same building, or if there be none, to one adjacent to it; because these wires, being in constant use, are less liable to be out of order than those used for fire-alarm purposes only, and comparatively rarely tested. It is furnished with a device by which, when it is set in action from the operation of a detector, it automatically cuts out the telephone connection in the building and makes connection for itself, sending its alarm to the telephone exchange. These alarms are readily distinguishable by the telephone operator at the exchange, not only because of their marked

difference in tone from that of the ordinary magneto calls, but also because the telegraphic fire alarm number of the transmitter is audibly communicated fifteen times successively, in regular periodic impulses, impossible to misunderstand.

Upon the operator distinguishing the first one or two successive signals, or, in fact, merely recognizing their character, he plugs the line into the telephone line of the fire department, without moving from his seat in front of the switchboard, thereby making the special building conductor continuous all the way to the fire department. In that manner the alarms are transmitted direct to the fire department, notwithstanding that either of the two lines may have been in use when the automatic alarms started to come into the exchange. The transmitter communicates its fifteen successive signals in a period of two minutes, and at the end of that or any predetermined period, it automatically cuts out its own connection at the building, thereby restoring the telephone instrument to its normal connection with the line.

The alarms are distinguished at the telegraph bureau of the fire department by being printed upon a self-starting register, which records the impulses of current corresponding with the assigned fire alarm numbers of the transmitters in the usual way.

In cities where there are no telegraph operators employed at the fire department headquarters and where automatic repeaters are used in substitution, the alarms are caused to work directly through such automatic repeaters by extending any one of the city's fire-alarm circuits into the local telephone exchange and connecting a special type of relay direct to such city fire-alarm circuit, and upon receipt of alarms by the telephone operator, the latter can shunt the same into the city circuit by merely moving a switch connecting the subscriber's line with such special relay. If necessary, even this simple operation on the part of the telephone operator may be dispensed with, by providing automatic switches in place of manual switches, the former energized by electro-magnets wound to correspond with

the fire-alarm transmitters in the building, as, for example, a direct current instead of an alternating current, so as to be unaffected by impulses of alternating current from the use of the common type of magneto call movements used by telephone subscribers for the purpose of ringing up the exchange.

In relation to the state of the art in general, the system above described presents the following material advantages.

(1) It avoids the use of electric batteries in the various buildings and the constant attention they require to sustain them, and substitutes purely mechanical power that becomes operative only from the heat of a fire.

(2) It avoids the use of electric wires within the buildings and their attendant breakage and displacement, and substitutes iron pipe conductors, the same being as durable and permanent as the ordinary gas piping of a building.

(3) It avoids the use of the common type of electro-contact thermostats, which are variable and erratic under practical conditions, as they depend upon minute adjustments that appear to be impossible to be maintained with reliability and uniformity, and substitutes purely mechanical thermostats, rendered operative by the melting of fusible solder.

With regard to the transmission of the telegraphic alarms from the buildings to the fire department, the use of magneto-electric machines and existing telephone conductors presents the following advantages:

(1) It avoids the maintenance of the necessary closed-circuit and open-circuit batteries at a central station and the equipment of recording and repeating instruments at such point.

(2) It avoids the use of private metallic circuits, where two coincident line troubles cut off communication from all buildings located between such two foreign line troubles.

(3) It avoids the constant liability of signals interfering with each other by coming in together on the same circuit, and thereby conflicting and being rendered unintelligible.

(4) It avoids the use of overhead wires and their main-

tenance contrary to the regulations of the city authorities, and in many instances against the wishes or even without the knowledge of the owners of the buildings to which these wires are attached.

On the whole, the system in brief presents the following affirmative advantages:

(1) A purely mechanical local power.
(2) A purely mechanical thermostat.
(3) Iron pipe conductors.
(4) A purely mechanical annunciator.
(5) A purely mechanical electro-transmitter.
(6) An independent (underground) circuit, for each building, constantly used, and for that reason constantly tested.
(7) Either a slight manual operation at the exchange to make the signal go direct to the fire department, without the delay of re-transmission, or automatic switches in place of any operation whatever by operators.

The system in question, both in its broad conception and mechanical execution of details, evidences a marked intelligence and discrimination, in consideration of which, and of the beneficial results demonstrated by many practical tests, the Institute recommends the award of the John Scott Legacy Premium and Medal to Albert Goldstein, for his pneumatic fire-alarm telegraph system.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, February 6, 1895.

JOS. M. WILSON, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by
SAMUEL SARTAIN, *Chairman.*

Award confirmed by the Board of Directors of City Trusts, June 10, 1895.

APPENDIX.

To illustrate the preceding report, *Plate A* represents a perspective view of a standard pneumatic fire-alarm equipment as installed in a building, showing (1) the thermostats, (2) the iron pipe conductors, (3) the annunciating box, and (4) the electro-transmitter or generator. The latter is con-

nected to the local telephone circuit by three wires, so as to be short-circuited under ordinary conditions (in order to avoid making any resistance in the circuit); but upon the operation of a thermostat, the relative positions of the generator and telephone become reversed, thereby short-circuiting the latter, but only for the predetermined interval in which the telegraphic alarms are transmitted.

To indicate the security of such circuits, as afforded by the modern type of telephone subway construction, there is shown in the same plate a perspective view of the individual metallic circuit as it enters the cable box on the distributing pole, and thence goes underground, as shown by the view of the cables in the man-hole, including ducts and conduits. In addition to the permanence of such construction it possesses the advantage of the frequent test of each circuit as afforded by the almost constant telephonic communication over same, without, however, such use interfering with the automatic transmission of telegraphic alarms, when necessary.

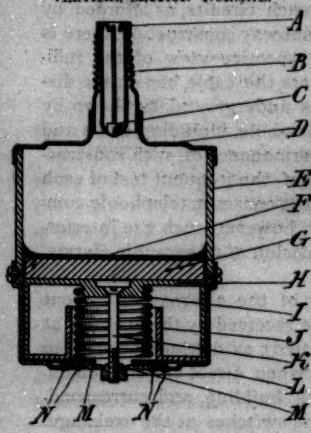
Plate B shows a generator of the alternating current type, the alarms from which are received by the operator at the exchange (and re-transmitted), as distinguished from purely automatic transmission, when direct current generators are used at the subscriber's building, and correspondingly wound relays or automatic switches at the exchange.

Plate C represents the local annunciating box with separate pipes and shutter drops to correspond with the respective floors or apartments. A circuit-breaking device of the usual type is contained therein, so that it can be connected in series with any existing closed circuit, such as a city fire-alarm circuit, district telegraph, or private metallic circuit running to a central station, either in addition to the telephone exchange connection, or independent of it, where for any reason the latter cannot be procured.

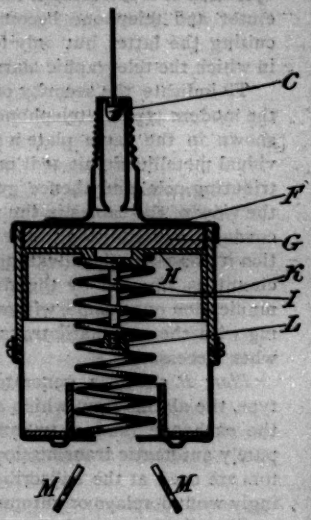
Fig. 1 is a vertical section of the thermostat or actuating device in the normal condition; *Fig. 2* is a vertical section of same in operative connection, and *Fig. 3* is a side elevation in perspective. The respective parts are lettered in detail, as follows: *A* is a small cap that fits over the outlet

or nozzle, and has inverted lugs for the purpose of retaining the contained check-valve, when the latter is forced outward from the internal air pressure; *B* is the nozzle, with stand-

VERTICAL SECTION—*NORMAL.*



VERTICAL SECTION—*OPERATIVE.*



BOTTOM VIEW—*NORMAL.*

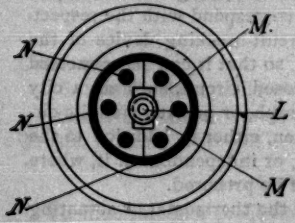


FIG. 1.

BOTTOM VIEW—*OPERATIVE.*

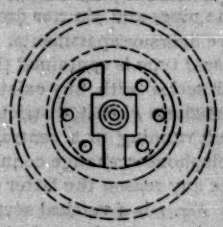


FIG. 2.

ard pipe thread (1-8) for screwing the thermostat into pipe fitting; *C* is a gravity check-valve, which yields to the internal air pressure, but resists it from any other thermo-

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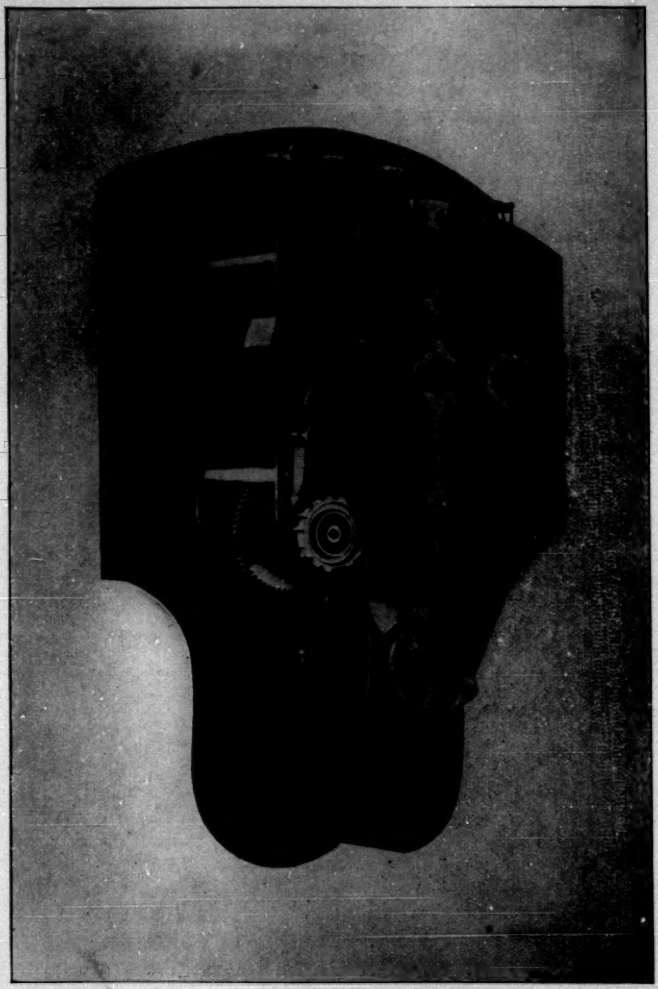

PLATE B.—AUTOMATIC MAGNETO GENERATOR.
(DIMENSIONS OF WORKS, WITHOUT CASE, 7 x 13 INCHES.)

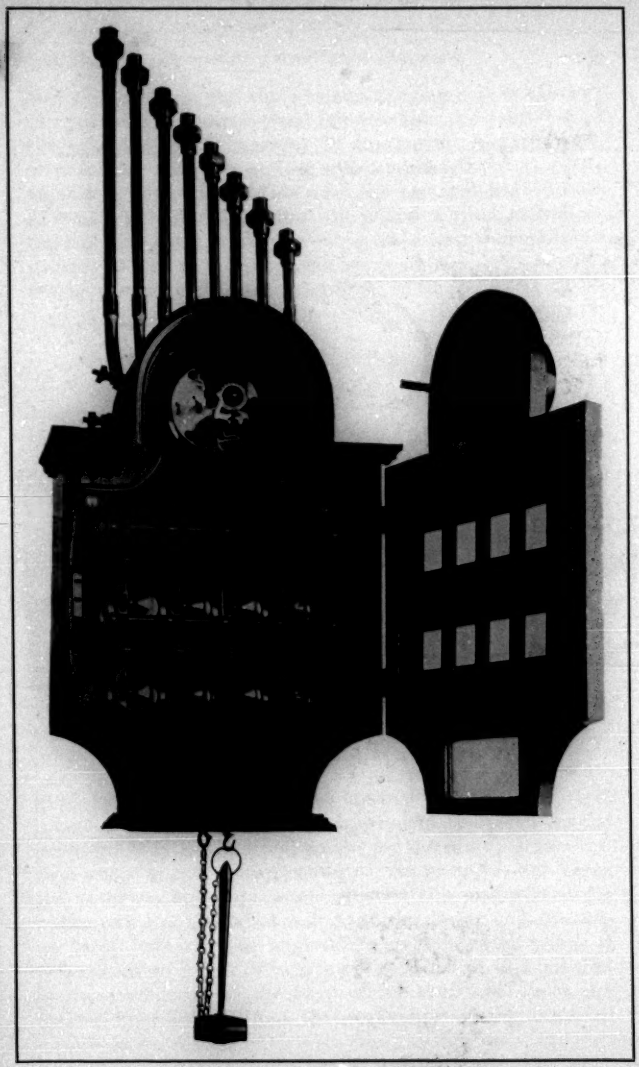

PLATE C.—AUTOMATIC ANNUNCIATING AND MANUAL SIGNAL BOX.
(DIMENSIONS OF WORKS, WITHOUT CASE, 9 X 13 INCHES.)

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stat connected to the same conductor pipe; *D* is the top cap over the air cylinder, and is brazed at the joints; *E* is the cylinder or air chamber of thermostat, the contents of which are normally at atmospheric pressure; *F* is a paraffine-wax seal, which fuses from the external heat in case of fire, and thereby lubricates the piston motion, as well as renders the same air-tight; *G* is an asbestos washer or packing, boiled in melted paraffine before use; *H* is a loose-fitting piston or plunger, cylindrical in shape, so as to be

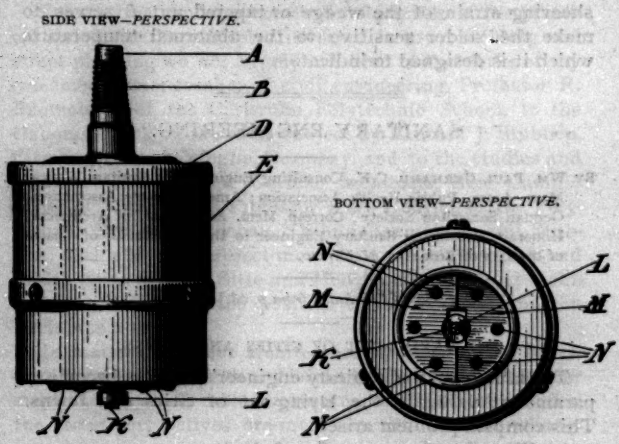

FIG. 3.

guided in movement; *I* is a normally compressed steel (piano wire) spring, specially drawn and tempered for the purpose; *J* is a cylindrical guide for the same; *K* is a vertical screw or rod in the center of the spring *I*, and keeps the latter under compression between the piston *H* at the upper end and a tapered nut *L* at the lower end, the latter being held at right angles, like a shoulder, by means of two halves of a disk *M*, which are retained in this position by being soldered to the base of the thermostat with the fusible metal *N*. When the resistance of the latter is

diminished by the heat of an incipient fire, the two halves of the disk *M* spread apart from the force of the shearing strain exerted by the wedge or tapered nut *L*, thereby permitting the latter to pass between, and the spring *I*, consequently, to push the piston and washer forward and compress the contained air of the cylinder. The possibility of premature rupture of the fusible solder *N* is resisted by a circular ridge or abutment at the circumference of the two halves of the disk *M*, while, on the other hand, the constant shearing strain of the wedge or tapered nut *L* serves to make the solder sensitive to the abnormal temperature which it is designed to indicate.

SANITARY ENGINEERING.

By Wm. Paul Gerhard, C.E., Consulting Engineer for Sanitary Works; Mem. Amer. Public Health Association; Amer. Forestry Association; German Samaritan Society; Corresp. Mem. Amer. Inst. of Architects; Honorary Consulting Sanitary Engineer to the Department of Health of the City of Brooklyn, N. Y., etc.

[*Concluded from p. 68.*]

THE LAYING-OUT OF CITIES AND TOWNS.

The municipal and sanitary engineer's services become of paramount value in the laying-out of cities and towns. This complex problem arises:

(1) When new towns are founded.

(2) When, owing to the tendency of men to congregate in cities, these grow so quickly as to require the extension of their limits by the addition of new outlying districts.

(3) When the alteration of the older parts of a city becomes necessary, owing to the increased internal traffic which requires the extension or widening of streets, or when, as in European cities, the abolishment of fortifications in old towns and the tearing down and planing off of fortified walls causes a sudden growth and expansion of the town, and calls for a reconstruction of its narrow streets, simultaneously with the building up of its outer districts.

In all such cases the actual work of extension, in whole or in part, should be carried out under a general, well-considered plan, and under the guidance of certain practical as well as æsthetic principles. We must confess, at the outset, that little work of the kind has, in the past, been done in the United States in the way suggested, for, as a rule, American cities grow in a haphazard fashion and often so quickly as to render the study of the problem and the preparation of plans out of the question.

For a learned and systematic consideration of the practical and æsthetic principles involved in town building and street planning we are largely indebted to the works of my esteemed former teacher of civil engineering, Professor R. Baumeister, of the Carlsruhe Polytechnic School, to the elaborate work on the same subject by Baurath J. Stübben, City Engineer of Cologne, Germany, and to the studies and labors of two eminent German architects, Herr Camillo Sitte, of Vienna, and Professor Karl Henrici, of the Polytechnic School at Aachen. While Baumeister and Stübben deal with the subject more from an engineering and health point of view, Sitte and Henrici discuss street architecture chiefly from the position of the æsthetic and the landscape architect.

In matters of street architecture there is a vast difference between European and American cities. The former are, as a rule, much more interesting, the sights are grander, the street perspectives are more beautiful and ever-changing, the impressions of the vivid and varied traffic are more lasting; monumental buildings are placed to better advantage; waterways are more picturesque, and more glimpses are afforded of gardens, parks and rows of trees used for the ornamentation of the streets. Compared with European streets, the American city streets lack architectural effects; we have too many dull, stupid and monotonous rows of houses, each house being identical with its neighbors, and in the business portions the ugly sky-scrapers of many stories shut out the light of day, the blue of the sky and the pure air of heaven, while there is a lack of prospects and outlooks of ever-varying views, and of expressions and im-

pressions of beauty. In all this, I firmly believe, we have very much to learn from the older cities of Europe.

The planning of extensions of existing cities and the laying out of new towns require a very careful consideration of the numerous engineering works located both above and below the streets, and of the constructive, sanitary and æsthetic features of streets, squares and buildings. Broadly speaking, the requirements relate to traffic, to building and to sanitation. It is fortunate that in street planning and street architecture, the æsthetic and art requirements coincide with the requirements of hygiene. Everything in this line which helps to embellish a city has also sanitary advantages. I, therefore, crave your pardon, if, in the following, I mention matters which at first blush may appear to you to be more of an architectural nature, or belonging to landscape rather than to sanitary engineering.

In developing the plan of a city we should consider the mode of living of the inhabitants and the character of its habitations and other buildings. Regarding dwelling houses we may distinguish the open or detached, and the closed, block or terrace arrangement of houses. A city may generally be divided into several districts, such as (*a*) the manufacturing districts, with factories, industrial establishments, warehouses for wholesale trade, and bonded warehouses; (*b*) the workingmen's districts, comprising laborers' dwellings or cottages, and, in some cities, the tenement-house districts, although it is to be hoped that tenement-houses will ultimately disappear, and that the aggregation of large numbers of people into small, dark, overcrowded and unhealthful apartments will cease; (*c*) the shopping districts, containing the large shops and stores, generally located on the main thoroughfares of traffic, and constituting the retail business section of cities; (*d*) the business section proper, including the centers of wholesale and general business, the exchanges, the banks, the chamber of commerce, the post-office; (*e*) the sections in which the railroad terminals are located, including travellers' headquarters, hotels, express offices, etc.; (*f*) the residential districts, made up by the mansions of the rich and by the dwellings of the well-to-do people.

In laying out the principal thoroughfares on the general plan, we should carefully consider the size, character and the centers of traffic, as well as the radial, diagonal, longitudinal and belt traffic. We should make provision for the traffic on foot, for heavy truck or wagon traffic, for carriage, cab and hack traffic, for equestrians, for stage lines, and tramways, whether propelled by cables, electricity or by horses; finally, we should include the steam railroads and transportation by water, and endeavor to establish some well-considered system in the traffic of a city.

The principal axiom to be followed is that city streets should be laid out not only for traffic, but also with an eye to permanent beauty, by bringing architectural structures and sculptural monuments into agreeable position or into effectual grouping. The requirement that engineering and landscape architecture are to be combined should never be lost sight of in street planning. It is of still greater importance in the laying out of boulevards and of parks, drives and speedways.

The width of streets should be determined according to their importance or the probable amount of traffic. The grade or longitudinal profile, the cross section of the street, its surface drainage, the facility for building, all these matters should be considered.

The rectangular system of streets, so prevalent in American cities, does not merit approval on æsthetic, much less on practical grounds. In a skilfully laid out network of city streets, straight lines of too great length are avoided as being very monotonous and as wearying the eye; gentle curves or variations in the width help. Intersections of thoroughfares should be utilized and set aside for public buildings, such as railroad stations, theatres, churches, museums, banks, telegraph and post offices, court-houses and markets. Schools and hospitals should be relegated to the quieter side streets. Likewise should the street perspectives be beautified by artificial ornaments, monuments, and sculptural works set with a good background, or graceful statues, or by water jets and fountains, or by arcades. On important street crossings and squares there should be

provided landing places affording safety for pedestrians crossing a thoroughfare crowded with vehicles, and these landing places may be adorned with candelabras or with pavilions, with fountains or public seats and benches, or with graceful shrubbery. The intersection of important streets should be utilized for squares, and the artistic embellishment of these should always be considered. Advantage should be taken of the natural configuration of the ground in the laying out of streets. The uneducated eye must be taught to appreciate the beauty of undulating ground, in which opportunity is afforded to look down from the high points on beautiful layouts of commons, on public parks, or to look up from the lower points to buildings or monuments on commanding sites. The beauty of many an imposing architectural structure is, in American cities, lost, owing to the impossibility of looking up to the building.

The division of the cross-section of wide streets into footpath, roadway and boulevard, offers opportunity for landscape effects by providing special promenades in the center, with rows of shade trees or shrubbery and flowerbeds, and the traffic may be benefited by separating the carriages, the horseback riders and the heavy teams and trucks.

Regarding the proposed width of streets and the distance between streets or the depth of the blocks, it should be noted that too great width of carriage-way is undesirable, as it tends to increase the dust and dirt, and the cost of street maintenance. Likewise should the distance between streets be limited, for very deep blocks are undesirable and lead, where the land is valuable, to a building up of the interior of blocks with rear dwellings, or with factories, workshops and storage buildings. All buildings should have a frontage on the public street, and the rear part of lots should be utilized for yards; or better, the center of the block may be laid out in well-kept private gardens or pleasure grounds, with low and open dividing lattice fences, or else all the yards in a block may be combined into one large open space, with drying yard, playground and lawn, thus providing plenty of pure air and daylight to the rear

of our dwellings. The ideal mode of building from a sanitary point of view is the detached method, but it is only adapted to the suburbs and outlying villa districts of cities.

Public squares in cities may either serve for general traffic, or for meeting places, for markets, for approaches to prominent buildings, such as city halls, churches, synagogues, theatres, museums of art and of natural history, or schools, or else they are intended for adornment and as locations for monuments. Open squares in cities have a distinct sanitary value, because they afford breathing spaces. If they are laid out as a public garden, common or park, with lawns and flower-beds, shrubs and trees, benches and seats, they afford opportunity for recreation, constitute playgrounds for city children, they promote the healthfulness of a city by lessening the street dust, removing the street noise, and by maintaining a purer atmosphere. Squares and parks are, therefore, aptly termed the "lungs of a great city."

In addition to promenades liberally planted with trees, and open spaces and public gardens, a large city should have public parks and airing grounds, to afford its inhabitants opportunity for taking exercise in the open air. Where possible, the parks should be connected by boulevards, and these, laid out by a clever landscape artist, may afford pretty outlooks on the city, onto the broad expanse of its surroundings, or a distant view of the water.

As regards their location in relation to the plan of the city, all public and important business buildings and structures may be divided into three classes. The first class embraces buildings which are business centers and which *centralize* the traffic, such as city halls, court-houses, exchanges and bourses, banks, main post-offices, houses of parliament, or capitol buildings, judicial buildings, municipal government buildings, halls of record, telegraph and telephone headquarters, hotels, museums, libraries, terminal depots, railroad stations, ferry-houses and docks for arrival and departure of steamships. To the second class of buildings belong those which have a tendency to

distribute traffic, such as sub-stations of post-offices, public telegraph and telephone stations, churches, schools, police stations, open and covered market halls, exhibition buildings, theatres, circus, concert halls, club-houses, other places of amusement, fire-engine houses, people's public baths and wash houses, asylums, livery stables, also buildings in public parks. The third class consists of buildings which should be confined as much as possible to *special outlying sections* of a city, and of these I mention military barracks and military drill grounds, jails and prisons, hospitals, reformatories and orphan asylums, cemeteries and mausoleums, abattoirs and slaughter-houses, cattle and stock-yards, noxious trades, gas works, waterworks pumping stations, reservoirs, standpipes, settling and filtering basins, sewage pump and disposal works, garbage dumps and the like.

In European cities generally much more attention is paid to a good and suitable selection of sites for monumental and public buildings than here. It is unusual to find a church, or a theatre, or a school, located in the middle of a block. Open spaces on at least three sides are required for churches, museums, schools, hospitals and theatres, with the incidental advantage of gaining better light and air and better approaches to the buildings, and of having better and more numerous exits in case of danger from fire or a panic.

The water-fronts of harbor towns or of cities situated on the banks of a river are also worthy of embellishment and improvement. Much remains to be accomplished in American cities in this respect, for here the water-fronts are usually the least attractive portion of a city, whereas in cities of the continent the reverse is often the case. Water-courses or canals flowing through the heart of cities should be kept clean, and may serve to beautify the same, if all liquid or solid filth is carefully excluded, if the banks are rectified and protected, if they are hemmed in by well-built stone embankments, with gardens or parkways, and if picturesque and ornamental bridges are carried over the same. Natural coves or basins may be made points of great attraction, as every one will concede who has ever seen the beautiful Al-

ster-basin in the city of Hamburg, Germany, with its boulevards and garden banks, its hundreds of row-boats, sail-boats, and little steamers on the water, travelling to and fro, and enlivening the landscape.

Some general and sanitary requirements of a well-studied city improvement plan are the following: good location; protection against high water and floods of rivers; dryness and cleanliness of building soil; ample means for traffic, on land and by water; facility for future enlargement; ample public squares, gardens and parks; well-lighted streets and well-laid and well-kept pavements; perfect drainage, sewerage and sewage disposal; easy mode of removal of refuse and destruction of garbage; healthful habitations; freedom from soil contamination; prevention of pollution of rivers, lakes, coves or water-courses; pure drinking water supply and ample supply of water for all other purposes; ample provision for plenty of light and air in the streets, in the centers of house-blocks and in the habitations; avoidance of smoke nuisance, and noiselessness of streets.

The execution of the improvement or enlargement plan for a city requires a large number of well-devised engineering and architectural structures, above as well as below the street surface. For purposes of a water supply a city needs a distributing system of pipe mains, with shut-offs, house taps, street hydrants for fire department use and for washing and sprinkling the gutters and streets, also public drinking fountains, horse-watering troughs, ornamental fountains, etc. For purposes of sewerage the city requires underground pipes and masonry conduits, man-holes, inlets, flush-tanks, house connections, gutters, catch-basins, also public urinals and public water-closet accommodations. Then again, a city requires means and facilities for public street- and house-lighting by either gas or electricity, involving a distributing system of gas pipes, mains, sub-mains and branches, valves and siphon boxes; house and street lamp services, street lamps and candelabras, and, on the other hand, electric wires or cables, subways and electric light poles. For facilitating intercommunication, a city requires telephone and telegraph wires for the public, for the police

and fire departments, with fire alarm boxes, telegraph and telephone stations, and pneumatic conduits for parcels and mail service. Other underground conduits for the distribution of light, heat and power, comprise steam mains, pipes for water, fuel or natural gas, conduits for hot water and for compressed air, electric cables and pipes for distribution of cold refrigeration. On the street surface the traffic requires pavements for carriages and trucks; sidewalks for pedestrians; roads for equestrians; horse, electric and cable roads, with their underground cable and trolley wire conduits—overhead wires should not be countenanced—elevated roads and underground railroads, etc.

The street traffic of a city also requires certain accessories for public information and public convenience, such as house-numbers, street-signs, warning-signs at grade crossings (I may say here that railroad crossings on a level with streets should be abolished in well-laid-out cities), street-clocks, columns for advertising purposes, fire-alarms, signal boxes, columns for weather indications, waiting pavilions for street railways or steamers, public conveniences, lamp-posts, letter-boxes, news stands and pavilions for sale of refreshments, music pavilions, seats and benches, etc. There is no reason why these utilitarian devices should not serve as tasteful embellishments of our streets by having them designed in an artistic manner.

It is finally necessary that a city improvement plan be carried out in accordance with well-framed building and sanitary regulations. Such building regulations refer principally to construction and stability, to safety from fire, to traffic considerations, and to healthfulness of buildings. Those relating to the salubrity of buildings, and to maintenance of the public health, are doubtless of the greatest importance. The rules should limit the size of the area of lots available for building; they should regulate the height of buildings in proportion to the width of the street, to secure light, air and sunshine to the houses. They should control the period when newly-finished dwellings are to be occupied, and should prohibit cellar habitations. Other regulations should have reference to the filling-in material

used for low building lots, to the drainage of low land subject to overflow, to the maintenance of cleanliness on vacant lots in cities, to factories, workshops, stores, and to noxious trades, to schools, places of assembly, like theatres, lecture halls and churches. In order to facilitate building operations, it may be wise to apply building regulations of less severity to the outer districts of a city, or, in other words, to arrange for several distinct building zones.

The engineering works enumerated and described form together a large sanitary system, which must be planned by sanitary engineers to establish safeguards for the public health in centers of population, and which, assisted by a wise sanitary administration, helps to diminish the death-rate of a city.

I had intended to speak to you more fully about matters connected with the general sanitation of towns, some of which I have just been able to scan very briefly, such as the relations of sunlight and sun warmth to health, the avoidance of outdoor and indoor dust, the prevention of the pollution of town air by smoke, vapors and fumes, the planting of trees in wide streets, the laying out of gardens, public squares and city parks and their sanitary benefit to the town dwellers, the means of transportation, storage and sale of the food supply, and other topics, but the time at my disposal does not permit more than the casual reference to these sanitary problems. Nor can I discuss to-night the city graveyards, cemeteries, mausoleums, crematories and other modes of preservation and disposal of the dead, nor the drainage of swamps and malarious districts, the prevention of inundations and storm-floods and of drought, the sanitary influence of forests, the benefits due to forest culture, and the objects of city and village improvement and sanitary associations, all of which will at some time engage the sanitary engineer's attention.

Again, much as I would feel inclined to, I cannot touch to-night upon the sanitary engineer's duties in relation to habitations. The sanitation of the dwelling, the protection of buildings against the elements, the problem of hous-

ing the poor, tenement-house reform, the sanitary features of schoolhouse construction, the proper planning and arrangement of hospitals, of prisons, jails and military barracks, the establishment of people's baths in populous city districts to further bodily cleanliness and health of the working people, the arrangement of markets and of abattoirs, the disposal of dead animals, the construction of mortuaries and city morgues, the fire protection of buildings and of cities, the safety of audiences in theatres and general theatre hygiene—these are all matters pertaining in whole or in part to sanitary engineering.

Industrial hygiene, the sanitation of workshops, the prevention of machinery accidents in manufacturing establishments, the regulation of noxious and offensive trades, the abolishment of public nuisances, the healthfulness of summer hotels and summer resorts, present problems which it is often the business of the sanitary engineer to solve.

The hygiene of the travelling public requires, not only provision of comforts and conveniences, but, above all, of safety and cleanliness. In hotels this means unobstructed fire escapes and fireproof stairs, located, not around, but away from, the elevator shafts, perfect cleanliness of rooms, beds and bedding, bathing facilities, well-kept toilet rooms, safety from sewer gas in sleeping apartments, freedom from coal gas due to stove dampers, avoidance of gas leaks due to defective gas fixtures and the filtering of the water supply, and in particular of the table water.

Public conveyances, in which travellers are often carried for long distances huddled close together, need sanitation as much as our homes. Surface, street and elevated railroad cars should be thoroughly washed, cleaned and aired every night. The ventilation of railroad coaches, of sleeping cars, of railroad tunnels, of ferry boats and of steamship staterooms and berths afford sanitary problems which are not always easy to solve. The luxurious sleeping cars, in particular, could be much improved if more attention were paid to cleanliness and sanitation rather than to decoration and embellishment. Means of ventilating cars are often

absent, or, where they are provided, they are not effective, because they are not rightly handled by the train hands. Among more palpable defects I mention defective lighting, overheating, lack of cleanliness and of ventilation, unclean water tanks, with ice and water of doubtful purity and often mixed together, bad arrangement of car-hoppers, objectionable water-supplied pan-closets in compartment cars of vestibule trains, etc. There is in all cases some danger of the transmission of disease, such as typhoid fever, or consumption by the sputum of invalids. Railway and ship sanitation include much more than this, as you will admit when I recall to you the disgraceful unsanitary condition of many railroad stations, and when I remind you of the crowded steerage quarters on emigrant vessels.

A large part of the practice of a sanitary engineer refers to sanitary inspections, whether examination of houses, or inspection of future building sites for institutions, or sanitary surveys of cities and towns. His acquirements also render him well qualified to assist in drawing up building laws and sanitary ordinances, to see to their proper enforcement in the position of sanitary, or building, or factory inspector, or to prepare in the office sanitary maps, profiles and diagrams of mortality in its relations to meteorological and sanitary conditions.

Another part of his work consists in rendering expert services in cases of litigation pertaining to sanitary works or sanitary patents. To give testimony as an expert witness in court is not always an agreeable duty, particularly under the custom prevalent in the United States, under which experts are engaged by both the plaintiff and the defendant. It is far preferable, to my mind, that experts be retained by the court only, as is the rule in some European countries. I also hold that it were better if experts in sanitary engineering cases were confined to testifying to facts only, and not required to answer hypothetical questions. In any case, they should limit themselves to testimony relating to sanitary engineering questions, and decline to enter into a discussion of problems belonging to sanitary science or the germ theory of disease. Even a well-qualified and learned

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sanitary engineer should not offer opinions in court cases as to what may or may not be injurious to health. He should leave this to the medical officers, to the sanitarian, the biologist, and he should confine himself entirely to the constructive side of such works as health officers require for prevention of illness or to increase salubrity. Viewed in this light there is quite a distinction between a sanitary engineer and a sanitarian, which, in cases of litigation, the judge, as well as the attorneys who plead the case, should recognize.

Then again, I must remind you of the special work and duties of the sanitary engineer in case of sudden outbreaks of epidemics, or of sudden calamities or great disasters in civic life, such as earthquakes, river floods, and destructive conflagrations; and of the services which may be rendered by sanitary engineers in time of war, such as the erection of temporary hospitals for the wounded, the housing of soldiers in tents, the maintenance of cleanliness in the camp, the sanitation of battlefields and the prevention of war pestilence.

I trust my audience may have gained a tolerably clear insight into the numerous duties of the new profession; and now, having defined sanitary engineering and gained some knowledge of the education and the practice of the sanitary engineer, and of the problems which engage his attention, we are enabled to answer the question: "Who is not a sanitary engineer?" in the true sense and meaning of the term.

No one should be entitled to the name of "Sanitary Engineer" unless he is amply qualified, by study, special training and practical experience, to offer sound advice in all problems arising in his profession. The mere fact that a man is qualified in a single special branch, for instance, in house drainage or the plumbing work of buildings, should not entitle him to be regarded as a sanitary engineer.

I am quite aware of the fact that, in making this statement, I am stepping on dangerous ground, and that there will be some who may not agree with me. I do not believe in mincing such matters, and I do prefer always to call

things by their right names. Misuse of terms is misleading. A builder or contractor is not an architect, but the architect may, in certain cases, be a builder. A druggist or apothecary is not a doctor, though an educated physician may be, at times, a dispensing chemist. So likewise, a man who does the plumbing work of buildings, or who takes contracts for laying drains or sewers, or who confines himself to repairing or altering defects in house drainage, is not thereby qualified to be considered a sanitary engineer, but a sanitary engineer may, and often does, plan or carry out works of house drainage and interior plumbing arrangements.

A man does not become a physician by the mere act of hanging out a sign, on which he styles himself "M.D.," neither does a man become a sanitary engineer by merely adding these words to his trade sign, when he has obtained a license to run water pipes or to lay sewers, or when he is appointed inspector of nuisances. The innocent public, however, may oftentimes be misled by signs of ambitious tradesmen, such as "Plumber, Gasfitter and Sanitary Engineer," or the still more pretentious sign, "Plumber and Consulting Engineer for Hydraulic and Sanitary Works."

I do not wish, however, to be misunderstood, nor that my words should be misinterpreted or misquoted. Nobody has a higher appreciation of intelligent and skilled mechanics and craftsmen than I, and it is far from me to underestimate the good work done by conscientious men of the trade. But the difference between a trade and a profession cannot be bridged over or eliminated by devices merely calculated to deceive the public. It is just as erroneous to call a man, or to take a man to be, a sanitary engineer, who has had no general engineering training, and whose knowledge and skill is confined to house drainage and plumbing, as it is to think a man cannot be an engineer because he does not build or run engines. And to go a step farther, physicians, when they have made a special study of preventive medicine and sanitary matters, should likewise not be considered sanitary engineers—the term "medical engineer" has even been compounded for the purpose—for they lack the tech-

nical experience and training absolutely required to qualify them for carrying out works of sanitary engineering.

To reiterate: Just as in medicine the eminent specialists must be physicians proficient in general medicine, so in the profession of engineering *the sanitary engineer should be a well-trained civil engineer.*

A few words, in conclusion, in regard to the *general* qualifications of the sanitary engineer. To my mind, he should be a man with the broadest possible general culture. He should not only have a thorough knowledge of his profession, but he should combine with it good business capacity. He should be faithful, conscientious, accurate, honest, trustworthy, sound in judgment and of absolute integrity of character. He should respect his brother engineers in order to win their respect. In order to deserve universal respect, he should, if he has decided to practise for himself, avoid sensational writing or advertising, and confine himself, if he is building up a practice, and is obliged to seek work, to such legitimate advertising as he may accomplish by insertion of a professional card in engineering journals; or by the opportunities which present themselves to him to demonstrate his qualifications and skill in works carried out from his designs or under his superintendence; by original contributions to the technical and engineering press; by the dissemination of essays, or by lectures. Much of the sanitary engineer's work is necessarily of a missionary character, as the public must be educated to appreciate the beneficial effects of sanitation. Not a little of his work requires patience and perseverance. It is, as a rule, up-hill work, until he finally reaps success and the merited reward of a widespread reputation.

Once a reputation is established, the sanitary engineer should be much more closely identified with public matters than has been the case in the past. Among the learned professions engineering occupies the foremost rank, and sanitary engineers in particular, are, by reason of their special training, exceptionally well fitted to be represented in City, State and National Boards of Health, in Boards of

Education and of Charities, in City Councils, city improvement societies and on citizens' committees.

The sooner the fact is recognized in the appointment to municipal offices or boards of public works, that engineering is not politics, the sooner will the reform movement, which has been so happily inaugurated in my own city, spread to other cities and bear good results.

OUR PENNSYLVANIA FORESTS.*

By Dr. J. T. Rothrock,
Secretary of the Pennsylvania Forestry Association.

The lecturer was introduced by the Secretary of the Institute and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

As a nation, our resources have usually been in advance of our needs, or in other words, there never has been a time when our capacity for production has not been in excess of our consumption. When we read of famine in other lands and think that in all our national life no such monster has ever stalked over any considerable portion of our country, we imagine that we are a peculiar people and under a special Divine protection. Anticipating no shortage in the future of any of the necessities of life, we have become reckless in the expenditure of what we have. We have absolutely lost sight of the fact that those who follow may, nay, must inevitably, suffer from our extravagance. Indeed, it is hardly too much to say that most of our legislation is based upon the present and takes almost no account of the future. Hardly a statesman whose name adorns our national records, has fairly looked into the future and shaped a specific policy, to anticipate wants which must press upon us unless we provide in advance for their advent. We have swept the buffalo from the plains, the fish from the streams,

*A lecture delivered before the Franklin Institute, January 4, 1895.

and are, as fast as possible, removing the forests to an extent which older nations have pronounced dangerous.

Before we consummate this last folly it may be well to ask ourselves just what our relations with the trees are. I shall consider this from three standpoints: (1) Forests as holding soil; (2) Forests as making soil; (3) Relation of the forests to the atmosphere; and finally shall draw some general conclusions from the statements previously made.

Forests retain, or hold, soil in its existing position. To illustrate this let me call attention to a hillside in Mifflin County, Pa. When I first knew that ground it was covered with timber. There was not a single gully upon its steep surface; and to this day, upon one end of the same hill, where the timber remains, no sign of wash appears. At present, from one end to the other of the timberless part, the hill is literally seamed and scored by gulches. Its value, as farm land, is absolutely nothing. Nor is this all. The soil, gravel, and even rocks, have been swept like an inundation to overflow and destroy the good soil on the flats below. Thus a two-fold injury has been wrought, one which threatens with each successive year to become worse unless arrested—at a considerable expense to the owner.

Let us take another illustration. Here is a scene in the Valley of Long Run, in Clinton County. The signs of a destructive inundation are everywhere apparent. Huge boulders and massive angular fragments of rocks dot the course of the stream. Fresh landslides show where the retaining soil below has been washed out. If you follow down the course of the stream you will see where the farms have been overflowed, where the original channel has been changed, a new one cut out, and where buildings have been undermined and swept off in the flood, involving a loss of human life which was sickening in its details.

Now return to the head of the stream and what do we find? A principal valley whose steep sides indicate a rapid delivery of water; a number of lateral, smaller valleys, with equally steep sides, and in every one a mountain stream, whose quick flow tells plainly enough with what impetuosity the water is delivered to the main channel.

From almost every part of this valley of Long Run, from even the remotest highlands, whose slopes send their contribution to swell the flood, the surface is as bare as fire and axe can make it; or where the barrenness is not already absolute, the lumberman is at work to complete the naked picture.

Do not misunderstand me. I am waging no war with the lumberman. He has his vocation, and the prosperity of the country demands his product. I am simply considering the facts.

Let us shift the scene, and go over into Rose Valley, in Lycoming County. As I drove through it I was struck by the fact that where the stumps still remained in the fields there were signs of good crops; but when I came to fields which were clear of stumps, and thereby showed that they had been longer under cultivation, generally, the crops appeared to have been smaller. In a word, there was less soil in the old fields than in the newer ones. Then when I came to the foot of the slopes I found what had become of the soil. It was washed out, and the stony surfaces in the older fields showed that it had gone, and explained why the crops were short.

It hardly seems necessary to devote any more space to a discussion of a principle which should be clear enough from the illustrations already given.

Let us now consider the second proposition—*that forests make soil.* First of all, we will note the growth of the mangrove thickets on the coast of Florida. The mangrove is a seaside plant in tropical regions clear around the world. It has its marked peculiarities, and among them is the one that the parent tree holds on to the seed, not only until it is perfectly matured, but until it has well begun its growth. When cast off, the young mangrove is a plantlet, or treelet, about a foot long. Thousands of these are yearly dropped from the older trees on the coast of Florida into the water and carried off by the wind and tide. Perhaps at low tide some of these are stranded on an oyster reef; where the soil is absolutely bare of any sign of what you would consider soil. Nothing but the crevices in a surface which is

covered by the repulsive slime of the ocean exists to offer the young mangrove a foothold. This, however, is sufficient. It is the one plant specially prepared to fill that place, and, once landed, it begins to establish itself and to grow. Nor is this all. No sooner are the roots fairly fastened, and the first trunk two or three feet high, than from the newly formed branches there are sent down hanging "air roots," which attach themselves to the reef as the parent stem had already done. Let us shift the scene and note the vigorous growth of the mangrove on the tropical shores of Jamaica. Near Port Morant one may find forests of this tree possibly seventy feet high. Over the tangled mass of roots one may walk for miles, a foot above the water, without coming in contact with it. This tangle of root and stem is not without its purpose in the general economy of nature. When the tree has attained its growth and fallen, to return by decay to the inorganic condition, it is in the eddies formed by these roots that the matter is retained. By slow degrees, in the course of ages, soil begins to appear above the surface of the water. Slime is buried beneath soil and on the rising earth, forests of a new kind, and possibly of greater utility, may appear.

Or, if we study the bald cypress, a lesson no less impressive is taught. We are quite too apt to think that this tree is specially fitted for bayous and mud-banks and will grow nowhere else. The fact is, the bald cypress is a tree of pliant constitution, well adapted to a wide range of conditions. I have seen it thriving where it grew up out of an asphalt pavement, and also photographed vigorous specimens of it where it stood out in the muddy water of the James River. When we find it in such positions as the one last named, the proper view is that it grows there because it is free from competition by occupying a place in which no other tree of the region will flourish. In the Southern States it forms just such forest masses as the mangrove does in Jamaica, except that it produces no such thickets of "air roots." These trees rise out of the brackish or fresh water, grow, mature, fall, decay, and out of their remains fresh soil is formed to produce dry ground for other crops.

One might be allowed here to call attention to the fact that on the soil formed by the mangrove and the bald cypress some of the most important crops of the world are produced. Indeed, a mangrove thicket strikingly illustrates some of the earlier features of "world-making." Its density, its emergence from the bosom of the ocean, produce an impression which is strikingly at variance with the ordinary course of things in temperate and sub-tropical regions to-day. Furthermore, when we consider the disappearing hemlock forests and recognize the possibilities of modern chemistry, it is hard to estimate what advantages it will place in the hands of the tanning industry, for it contains an enormous percentage of tannin.

No fact of science is better established than that the presence of moisture in the air, over any region, in temperate latitudes, tends to prevent the escape of the earth's heat. Professor Tyndall most forcibly explains that aqueous vapor in the atmosphere of England is as necessary for the vegetable life of that country as clothing is for man. It is equally well attested that plants in a vigorous condition are, during the growing periods, very active in giving off moisture to the air by transpiration, that they even transpire more than is received by the roots, which, of course, indicates another source of supply than the roots. The quantity transpired is very variable for different plants and under different atmospheric conditions; but from known facts, it is well accepted that the volume is enormous. The presence of this enormous body of water in the atmosphere must be accepted, and, if there, its potency must be acknowledged as a factor in climate, if not locally, then generally. It can hardly be doubtful that the change of a country from a wooded to a treeless condition must be accompanied by a change of climate, of moisture in the air, and consequently of temperature.

It appears that in our latitude the result must at least be a climate of greater extremes—extremes which would possibly affect the production of what are now important crops. Strict science has not the whole field to itself, and the observations of intelligent lay observers are at least

worthy of a respectful hearing. Some of these observers, whose remembrance extends back to the time when the country was under more positive woodland conditions, assert, as their opinion, that such changes have already taken place. For example, they assert that the period during which hay may be made has been appreciably reduced during the last half century. Owing to drier atmosphere, they say the grass must be cut at once when ripe, or be damaged as a forage by standing. I neither accept nor deny the statement, but content myself with remarking that the observation is entitled to a hearing, and that it opens the door for a productive line of meteorological research.

From the foregoing it would appear as if the relations between the surface of the country and the forests were most intimate and important. The natural sequence to this conclusion would be the inquiry: What proportion of the State should remain under forest cover? For Pennsylvania, with which we are most concerned, it would be safe to say that forests should be retained wherever they would be the most remunerative crop. This at once divests the subject of all sentiment, and places it under the same common-sense management which we accord to our crops, and it also places forestry where it should be, under agriculture. The mountain axes of the Commonwealth, the steeper ridges, the lowest swamps, where drainage is difficult, worn-out fields, where, owing to steep slopes and natural poverty of soil, it is impossible to retain enough of fertility in the soil to produce remunerative crops of the cereal grains, or even to maintain grass for dairy purposes—all these should be covered again with trees.

To this proposition there would be two natural inquiries. The first, "Is it possible?" The second, "Would it pay?" One may dismiss the first inquiry with the statement that forests may always be produced as a crop when accorded the care of a crop. It seems ridiculous to be obliged to reiterate that in Germany, France, Switzerland, Scandinavia and other European countries, forestry is as firmly established as any other branch of agriculture; but it appears to

be necessary, for to the average American the idea of producing forests is still little less than absurd. The idea is growing; but it will require years to firmly establish it *just where it is most needed.* The remaining inquiry, "Would it pay?" may be answered in two ways: first, does it pay to farm such land as we have indicated should be devoted to growth of forests; second, "Is there any other known way of utilizing these lands, unless they happen to have some mineral deposits?" It will not pay in one year, in five or in ten years; but it will pay, in the longer run, interest and principal on capital invested.

It is well, in this connection, to call attention to the following, which is part of a law now standing on our statute books:

"AN ACT

"For the encouragement of forest culture, and providing penalties for the injury and destruction of forests.

"SECTION 1. Be it enacted, etc., That in consideration of the public benefit to be derived from the planting and cultivation of forest or timber trees, the owner or owners of any land in this Commonwealth planted with forest or timber trees in number not less than 1,200 to the acre, shall, on making due proof thereof, be entitled to receive annually from the commissioners of their respective counties, during the period that the said trees are maintained in sound condition upon the said land, the following sums of money:

"For a period of ten years after the land has been so planted, a sum equal to ninety per centum of all the taxes annually assessed and paid upon the said laid, or so much of the said ninety per centum as shall not exceed the sum of forty-five cents per acre;

"For a second period of ten years, a sum equal to eighty per centum of the said taxes, or so much of the said eighty per centum as shall not exceed the sum of forty cents per acre;

"For a third and final period of ten years, a sum equal to fifty per centum of the said taxes, or so much of the said fifty per centum as shall not exceed the sum of twenty-five cents per acre;

"*Provided*, That it shall be lawful for the owner or owners of the said land, after the same has been so planted for at least ten years, to thin out and reduce the number of trees growing thereon to not less than 600 to the acre, so long as no portion of the said land shall be absolutely cleared of the said trees;

"*And provided also*, That the benefits of this act shall not be extended to nurserymen or others growing trees for sale for future planting.

"SEC. 2. The owner or owners of forest or timber land in this Commonwealth, which has been cleared of merchantable timber, who shall, within one year after the said land has been so cleared, have given notice to the commissioners of their respective counties that the said land is to be maintained in timber, and who shall maintain upon the said land young forest or timber trees in sound condition, in number at least 1,200 to the acre, shall, on making due proof thereof, be entitled to receive annually from the commissioners of their respective counties the sums of money mentioned in the first section of this act. *Provided*, That the first period of ten years shall be counted from the time that the said land has been cleared of merchantable timber, and that after the said first period of ten years, the number of trees upon the said land may be reduced as in the said first section is provided."

It is a striking example of the folly of men that they will pay taxes on unproductive land, maintain fences, and bestow their labor upon it, render it each year more and more impoverished and continue to do this in spite of the fact that it will yield them nothing in the end. This folly is the more striking when it has been shown, all over the State, that such a law as the above exists for the sole purpose of ameliorating the condition of those "small land owners" who need it most. But how shall one characterise the stupidity of a farmer who owns a few acres of half-grown oak on a barren, steep, hillside, with a slaty surface and a northern exposure, and who cuts it off to sell in a market which is on the very lowest round?

It is an old, threadbare argument, that substitutes for

wood will be found. The statement is doubtless true, and might have some weight were it not for the fact that new uses are also being found for it much more rapidly than the substitutes for it are. The plain undeniable fact is, that wood will always remain almost as much an article of prime necessity as water.

There is another aspect of the problem which may well be considered: rates of interest tend to become lower as countries become better settled and business reaches a condition approaching an equilibrium. Contrast, for example, the interest on capital invested in England, and in Oregon and Washington. The 8 per cent. almost invariably comes from the lands to the west of us, and the undoubted tendency is for good securities to command lower rates. There is an evident exception to this general rule. Our population is becoming more dense, our timber-land areas are becoming more and more depleted, until it requires no prophetic eye to see the practical obliteration of important lines of business in this Commonwealth. In other words, the demand is continually increasing, and the supply as certainly decreasing. The inevitable tendency must be to increase the value of standing timber.

Thus far no allusion has been made to the spontaneous restoration of our forests. It is probably safe to say that in no temperate region is this tendency more marked. I might even go further, and say that the quantity of wood which an acre will produce spontaneously each year is a perpetual marvel to the European forester. It seems to be equally a marvel to our own people that when once a forest is removed it is not succeeded promptly by another of the same kind. As a matter of fact, there is no more reason to expect a perpetual succession of the same kind of timber than there is to expect that, from a single sowing, men should reap a perpetual succession of the same kind of grain; and there is no more reason why the existing tendency should be used, as it often is, as an argument against tree planting than there is why it should be used as an argument against grain sowing. The very same methods which ensure the crop we desire in the one case, will ensure

it in the other, the chief difference being the time of maturing. It is vastly important that the widespread error in regard to our most important tree, or what was our most important tree, the white pine, should be corrected. There is no species in which the tendency to restoration by seed is more marked. Over the State, here and there, in numberless places, one may see thriving groves of this tree coming on; nor does there seem to be any acceptable reason why the coming crop should not be as good as the first, if sufficient time be allowed for the wood to fully mature. It is well known to experts that the white pine does not select the richest soil for its favorite place of growth. This only makes it the more valuable. The one great foe to the young white pine is the unrestrained forest fires. It seems to be a wretched public policy which permits land to lie for half a century unproductive after its white pine crop had been removed. What shall be said of the policy which declines even to protect the spontaneous bounty which nature offers, but allows fires, year after year, to destroy the coming timber crop?

I do not draw upon my imagination when I propose this question, but at this moment can point out extensive areas in this State, which are now a picture of desolation, but which, under a wise State policy, should have been on the verge of reaping a harvest worth millions of dollars for its second growth of timber. One of the shortcomings which will be hard for the next generation to excuse, will be that we have stolidly ignored their interests, so far as protection of our timber resources are concerned. Yet it must not be forgotten that the present generation is the first one, of civilised men, born on American soil, to whom a possible scarcity of timber, or an unfortunate train of circumstances growing out of that scarcity, has presented itself as a present pressing problem. To those who preceded us, the problem was what to do with the excess. Scarcity faces us, however, squarely.

We recognize clearly enough two aspects of forestry—individual and State forestry. Let us briefly consider each.

State forestry may be said to concern itself with tree restoration and removal on soil which belongs to the State, or on soil which it is for the general interest that the State should control. Properly conducted, State forestry should consider ultimate consequences, and shape a perpetual policy which should extend forward indefinitely. It considers measures in the light of State perpetuity. It raises and solves the question as to what will be the ultimate effect on the proper conservation of water in the soil. How will stream beds be affected if this or that body of timber is destroyed, and what kind of timber can be grown most advantageously to the Commonwealth on any given area? Individual interests are, by it, wholly submerged in the general consideration: what will longest preserve and most benefit the community?

Of course, it is an open secret that State forestry has hitherto flourished most under the protection of a monarchical government. Perhaps it always will. With the recurring cries of "turn the rascals out," marking the change from one administration to another, it would be folly to expect a permanent policy, which could calmly contemplate any plan looking into the next century for its completion, however worthy that plan might be. The temptation to meddlesome interference is too great to be successfully resisted.

It follows, then, that the next best plan must be substituted for a general system of State forestry, and the latter appealed to only when it must be.

We believe that the highest function of the State is to allow every man the fullest chance to work out the best that is in him. Greater help than this becomes a doting paternalism, and is more likely to weaken than to strengthen the recipient. Now, to apply this principle, what is required? First, that each person should know how to act. Our public school system has this idea for its basis. It is more a public than a private benefit that we should know how to stamp out contagious disease, or to utilize present resources so as not to entail want upon the children we have begotten. In rational treatment of our forests, as a people, we are wholly

ignorant, and this public admission for the mass of the people is good for the national soul. But we are not hopelessly stupid. On the contrary, no people pick up a new idea with greater avidity, or comprehend it more promptly, if the moving motive is properly appealed to. To convey this instruction the State should own forest reservations where approved methods of tree culture could be illustrated, and where, at the same time, the State could have under its own absolute control such areas, as, if allowed to remain the property of the individual, would become a menace to the peace and prosperity of the community, by the frequent unrestricted deluges which would pour down from the steep and naked slopes. Ignorance of forestry to-day will cost this Commonwealth not less than $37,000,000 annually, in the near future, and will leave us with a great gap in the list of our most productive industries.

Furthermore, individual forestry should be encouraged, because the surface of the State must, to a certain extent, be covered with trees. The interest of the people demands their *presence*, as well as their *products*. It is merely a question whether the State shall, at a great cost, imperfectly preserve this equilibrium, or make it the interest of the individual to accomplish the same result for it, not only cheaper, but better. We may lay down the general proposition that a tree pays the State, in instant benefit, for the privilege of growing, every hour that it stands. Yet with this incontestable truth in plain view, our laws are actually placing a premium upon a system of forest destruction, which is as unnecessary as it is wasteful. As things now are, there is practically a prohibitory tax upon maintaining tracts of timber, which the future will need vastly more than we do. Or to put the facts in another shape, we may say that there are vast areas of woodland in this State which, in the last thirty years, have been confiscated by taxes, because these have aggregated more than the land can be sold for to-day. To make matters worse, during all this time, in spite of taxes being paid, the owner has received for the same property no protection whatever. The very same county commissioners who expend his money

refuse to accord the protection against forest fires which the law makes it their specific duty to furnish.

The time will come, and can come none too quickly, when not only will this gross injustice be abated, but when the true relation of the forests will be so plainly recognized that the individual will find the State encouragement which he needs to enable him to serve himself in serving the community.

INTERSTITIAL SPACE.

By T. Dunkin Paret.

London *Engineering*, for February 22, 1895, contains an abstract of a paper by Mr. Spencer R. Newberry read before the Ohio State Engineers' Society. This paper refers to the manufacturing of concrete. The abstract begins by stating that "it is well known that the voids in a mass of particles, all of nearly uniform size, are greater than when the dimensions of the particles vary largely, and hence in cement testing, the voids in standard sand, carefully ground to be uniform as possible, are much greater than in ordinary gravel." The abstract then states that "in making a concrete the materials should be mixed so as to fill the voids as full as possible, the amount of cement required for this being increased by ten to fifteen per cent. for safety." It also says "that a suitable addition of gravel to sand may strengthen the concrete," and gives a tabulation showing various proportions of cement, sand and gravel, with the crushing strength in pounds per square inch duly tabulated.

While this abstract may do injustice to Mr. Newberry's paper, its general effect is that produced by nearly all formulæ for the manufacture of concrete and by all articles in reference to such manufacture. In other words, there are certain facts and figures given, which are definite and specific, and a general vagueness in reference to that secret of quality which really lies (the cement being assumed as

always of equal quality) in *the proportioning of the filling to the interstitial space.*

If an absolute rule could be discovered by which proper proportions could, in all cases, be arrived at, such a rule ought to be of inestimable value, not alone in its relation to the manufacture of concrete, but also in reference to the proportioning of very many mixtures. Certain facts leading to the establishment of such a rule are to be found in a series of investigations concerning the manufacture of solid emery wheels, which investigations had their origin in a rather peculiar manner.

In an attempt to establish the varying qualities of different kinds of emery by the manufacture of these kinds into solid wheels, and by subsequent scientific tests, certain startling discrepancies were discovered. A number of wheels made by exactly the same formula were found to differ greatly, and various facts indicated at once and unquestionably that the difference was not due to the intrinsic quality of the emery. The question was then carefully considered as to how exactness of formula could be arrived at; for it is evident that, in a mineral like emery, amounts of equal quantity by weight might differ considerably in volume. Further investigation made that fact apparent, which, indeed, seems evident on theory, that, in order that the mixture should be of the same formula, exact bulks ought to be taken, rather than exact weights. Wheels being made of different emery by the same formula, equal bulks of emery being taken, differences in quality were again discovered, clearly not due to the difference in the quality of the ore. The suspicion then arose that this difference was due to the amount of interstitial space, the theory being that there was more space in some cases than in others, and that, where there was less space, there was an excess of that material which was used to bind and fill. To settle this fact, a prolonged series of experiments was made, whose course was as follows: An accurately fitted cubic inch cell of planed cast iron was made, and this cell filled with emery. Three trials were made with each kind of emery. At each filling of the cell an equal number of taps was given with a mallet upon

a wooden rammer, and the cubic inch mass was carefully levelled at the top. A medicine dropper, after having been tested as to its uniformity of drop, was employed to fill the interstices between the emery with water. Three trials were made in each case, and it was at once discovered that while one brand of emery only required 136 drops to fill it, another kind required 152. As doubt might still exist as to whether the absorptive capacity depended entirely on the interstitial space or upon some possible porousness of the mineral (although emery is supposed to be practically impervious to water) the attempt was made to demonstrate whether the variation was due to porous absorption or to the variation of interstitial space. This was settled by taking grains of that quality which only took up 136 drops, and so treating them that the angular corners were worn off and the grains rounded. It was then found that they took up 155 drops.

In these facts there is nothing startling or new, it being well known that a mass of perfect spheres of one diameter would have more interstitial space than a mass of atoms of irregular sizes and shapes, whose flattened sides and angular points would so arrange themselves under pressure as to come in the closest contact and leave the least amount of interstitial space. But, while there is nothing new in the general result, it may be that no exact data are to be found of the same character as those now offered, and from which deductions can so safely be made. We furnish herewith a tabulation showing the numbers of minims of water required to fill the interstices in one cubic inch of emery, giving the weight of the cubic inch in each case, and the percentage by weight of water required to fill the interstices.

Name of Emery.	Number of Emery.	Minims of Water Required to Fill Interstices in 1 Cubic Inch Emery.	Weight of 1 Cubic Inch of Emery in Grains.	Per Cent. of Water by Weight Required to Fill Interstices in 1 Cubic Inch Emery.
Tanite Mills Emery	6 UC	131	545	14·95
" "	10	133	542	14·30
" "	14	137	539	14·75
" "	18	139	533	14·99
" "	24	140	530	15·20
" "	36	140	526	15·32
" "	54	141	522	15·51
" "	80	147	522	16·07
" "	100	153	512	16·85
" "	140	160	504	17·80
" "	180	164	502	18·17
" "	200	164	502	18·17
" "	Rx. R. F.	180	427	22·27
Average		148	516	16·32
Equal parts by weight of the above thirteen sizes		95	675	8·73
Tanite Mills Emery	20 UC	136	532	14·64
Wellington Mills Emery	20	149	531	16·02
Washington Mills Emery	20	152	529	16·24
Tanite Mills Emery	20 UCR	155	532	16·53

The emery used in above tabulation is numbered to correspond with the mesh of the wire cloth on which it was made; but as commercial emery answering to these numbers varies considerably in size, all of that which was used in these experiments was carefully sifted by hand on the same sieves.

The regularity of the progression in each series of numbers is remarkable from the fact that the experiments were not made in consecutive order, as tabulated, but the different numbers were taken entirely at random at different times covering several weeks. Three trials were made with each number of emery, the mould being first filled half full of emery, and then receiving ten light blows upon a wooden plunger, then filled level and receiving ten more light blows, then filled heaping and receiving five blows, then finally levelled and filled with water from the dropper. *The facts indicate clearly that the interstitial space does not depend entirely upon uniformity of size, but is governed largely by diversity of shape.*

The tabulation given in *Engineering*, and those generally given in reference to the manufacture of concrete, which

roughly state so many parts of cement, so many parts of sand, and so many of gravel, seem to us vague in the extreme; and it would appear that a process, analogous to that used in arriving at the interstitial space of emery, might be used easily, cheaply, practically, and with great effect, in the manufacture of concretes and other mixtures. Where concretes are made in quantity, stone crushers and sifting machines are commonly used. It would be an easy thing in every such case to have a cubic foot cell in which crushed stone (of the average size actually being produced by the stone crusher and sifter then in use), was filled, and the interstitial space of that very stone arrived at by the use of water or other fluid. In like manner both sand and gravel could be so sifted that the average size of each was ascertained, and the sand be used as a partial filler for the interstitial space of the gravel. While the crushing strength of concrete is no doubt largely affected by the cleanness, roughness and angularity of the freshly-crushed stone surfaces, and by the areas of the lime and silica which come in contact, it, nevertheless, seems evident that the crushing strength would be greatly modified by the amount of filling between the stone being so carefully proportioned to the interstitial space that, when that coarse stone was compressed to its utmost extent, the irregular space would be completely filled, while the faces of the stone which came nearest in contact had only a slight layer of filling between them.

In the subjoined table will be found a few facts concerning the interstitial space in crushed stone. To obtain the result shown in this brief tabulation, a rectangular box with a capacity of one cubic foot was used, which box was filled as nearly level as possible with stone and then weighed, the interstices filled with water, and the whole weighed the second time.

Name of Material.	Approximate Size in Inches.	Weight of 1 Cubic Foot of the Material.	Water Required to Fill Interstices Contained in 1 Cubic Foot of Material, Pounds.	Per Cent. of Water by Weight Required to Fill Interstices Contained in 1 Cubic Foot of Material.
Broken Ore (Emery)	3½ × 3½ × 2¼	126	29¼	18·83
" "	3½ × 2¼ × 1¼	116	32¼	21·75
" "	2 × 1¼ × ¾	121¼	31	20·36
Rounded Stone (from creek)	2¼ × 1½ × 2¼	95	27	22·13

On theory, it might have been imagined that the rounded stone would, as has been suggested for exact spheres, contain more interstitial space than the crushed ore, but the crushed material was so irregular that it formed bridges, and, unlike the fine emery grain and unlike the stone pounded down in cement and sand, it could not bed itself or become more compact, but remained in the loose position in which it was thrown. The facts which appear most striking in these investigations are a very regular increase of space and diminution in weight of emery grain, as this latter increases in fineness—and the increase of 12·91 per cent. of space due to the mere change of shape in the Tanite Mills emery marked respectively UC and UCR, and the very remarkable decrease in space and increase in weight where thirteen sizes were combined in one cubic inch. The facts here given are not presented as affording an adequate explanation of how a perfect cement can be made, but are rather intended to suggest to other investigators practically interested in the subject a method by which exact results can easily and cheaply be secured.

THE FRANKLIN INSTITUTE.

Stated Meeting of May 15, 1895.

MR. H. R. HEYL, Vice-President, in the Chair.

[The Chairman announced the paper of the evening, and introduced the speaker.]

THE BALL NOZZLE.

BY ARTHUR KITSON.

Among the multitude of inventions which, year by year, find their way to the patent office, none attract more attention than those inventions which appear to be of the nature of a paradox, and which the newspapers are fond of describing as "scientific puzzles."

Such inventions as the injector, by means of which water is forced into a steam boiler by the same pressure of steam as that contained in the boiler itself; the down-draft furnace, in which the air for combustion is supplied at the top of the fire instead of at the bottom; the system of heating rooms, by placing the hot-water pipes on the ceiling instead of on the floor—all such inventions which operate on the reverse plan to that with which we are accustomed, at first sight strike us as contrary to the natural order of things, and there is a tendency amongst a certain class to consider the phenomena as marvelous.

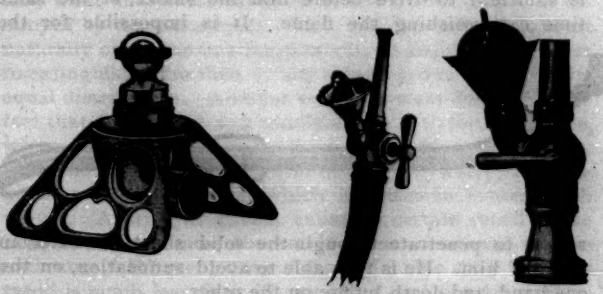
Of the very recent inventions that have in this way excited a great deal of discussion, what is known as the "ball nozzle" is probably the most widely advertised, and the principle governing it the least understood. Because in its operation it presents a phenomenon hitherto unobserved, it has been characterised by the press as contrary to the laws of science. There is, however, nothing of the miraculous or of the supernatural which cannot be explained by well-known scientific principles.

The "ball nozzle" is one of the simplest inventions ever designed. It consists merely of two parts: a bell-shaped or flaring-mouth nozzle, and a ball. The nozzle is connected

to a water or air supply, and the ball is placed loosely in the mouth of the nozzle. The ball steadfastly adheres to the nozzle and refuses to leave it, notwithstanding the great pressure of the issuing stream of air or water, and no matter what may be the position of the nozzle, whether vertical or horizontal, or whether the nozzle be turned directly towards the ground. As soon as the pressure is released and the supply of water ceases, the ball, obeying the law of gravity, falls. Variations of pressure from a few ounces to hundreds of pounds to the square inch fail to change the nature of the seeming paradox. In the case of water, the effect of the ball is to divide what would otherwise be a straight stream into a thin, fan-shaped spray, which spreads itself in a circle all around the nozzle. It is in this respect that its

utility arises. One of the essentials of a good water spray for agricultural purposes, or for lawn sprinkling, is the equal distribution of the water, so that an even supply can be furnished without much expenditure of energy. In this field the ball nozzle furnishes an almost perfect machine and seems to be the only genuine "rain-maker" now placed upon the market. With a pressure of 80 pounds to the square inch and a $\frac{3}{16}$ orifice, it is possible to distribute a water supply over a circular area 60 feet in diameter. Such a machine is a convenience and a labor-saving invention which only those who have been accustomed to the old-fashioned lawn-sprinklers can properly appreciate. As a method of distributing fresh air to railway cars or rooms, this invention also seems to fill an important function. But

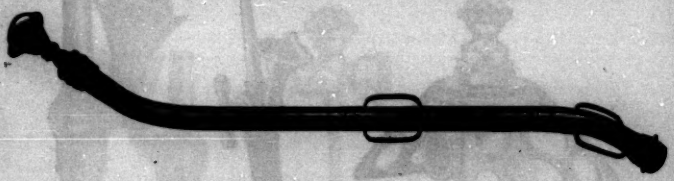
its most useful field, and one in which it comes as a blessing to humanity, is that of a fire extinguisher. It is one of the glories of science and of invention that, whilst the progress of the human mind in the realm of discovery often brings increased danger to human life, accompanying it—like a guardian angel—are those inventions which act as safeguards to protect life from those dangers to which inventions have given rise. With the ever-increasing dangers which increased speed of ocean travel has occasioned there have likewise arisen increased means and facilities for saving life. The danger attending the use of elevators brought forth the safety catch; and rapid transit, furnished by the trolley system, is soon to be accompanied with the fender,



which will make it almost impossible to sacrifice life in the accomplishment of so desirable an object.

Fire is at once man's preserver and his destroyer, and few things indispensable to him have proved so destructive of life and property as this element. It is estimated that, during the past twenty years, not less than 250,000 lives have been lost, and over $200,000,000 of property destroyed by fire in this country alone. An invention that will in any way mitigate or lessen this awful destruction of life and property must be hailed as one of the greatest benefits that the mind can confer upon society. It is in this field that the ball nozzle will serve its highest function. The large nozzles displayed here to-night are designed for this particular pur-

pose. You will see the end of the fire nozzle has two openings—one consisting of a straight orifice, from which a solid thick stream may be directed, as in the ordinary fire nozzle, and the other consisting of the ball nozzle. A three-way valve serves to direct the water to either of the openings. The *modus operandi* is as follows: A fireman, on reaching a building in which a fire is raging, first directs the straight stream against a window of the building in order to reach the fire with the spray. He then turns his valve and admits the water to the ball nozzle and directs it toward the fire. On entering the building he can proceed at once to meet the fire by placing the nozzle in front of him. He then becomes enveloped with a sheet of water, the force of which is sufficient to drive before him the smoke, at the same time extinguishing the flame. It is impossible for the



smoke to penetrate through the solid sheet of water in front of him. He is thus able to avoid suffocation, on the one hand, and death by fire on the other.

Those who have witnessed large fires and have studied the action of the ordinary fireman's hose, must have been surprised with the apparently slight effect which the water has had upon the fire. The reason is that the whole stream and force of water is directed upon a very small space, not many times larger than the orifice through which the water escapes. To overcome this defect it becomes necessary for the fireman to keep the nozzle moving so as to distribute the water. The result, however, is not satisfactory. Certain parts of the fire get more water than is sufficient to extinguish the flame, and other portions do not get any. Moreover, whilst the water is directed on one small area, the fire is making headway in other portions of the build-

ing. It must have occurred to many a man, especially firemen, that if the force could be immediately distributed from one source of supply, sufficient to cover the whole or a large part of a building, that fires could be much more rapidly extinguished and with less danger and loss. This is precisely what the ball nozzle does. Instead of concentrating large volumes of water upon a small area, the nozzle distributes it evenly over large areas, so that all parts of a room or side of a building can be treated equally to the fire-extinguishing element. It is estimated that fifty per cent. of the damage and loss occasioned from fires arises from the excessive use of water. This must be so from the ordinary fire apparatus, and it generally happens that what the water saves from the fire's ravages, is destroyed by the water itself. This evil the ball nozzle must naturally overcome to a large extent. It requires less water to extinguish a fire than by any other system, owing to its equal distribution. Another very important feature is the fact that one fireman can handle a hose with the ball nozzle, where ordinarily it requires three or four men. This seems to be the result of the distribution of the water from the nozzle and the manner in which it comes in contact with the air. A straight stream causes a certain recoil of the hose and necessitates the employment of several men to each hose. Frequent tests of the ball nozzle show that this recoil is much less than in any other, and can be successfully resisted by one man.

In this respect its utility is found to be most valuable.

I refer you to the circulars that have been placed in this hall, containing the endorsement of the various insurance companies and underwriters throughout this country. No institutions are more particular or more conservative about endorsing fire-extinguishing devices than insurance companies, and yet to none are such devices of more importance. Not less than 130 of these companies have endorsed this invention as an improved fire appliance. Judging from the numerous accidents that have occurred recently in private houses from defective flues and exploding lamps, it appears essential that some appliance for extinguishing

fire should be provided in every home, and it seems to me that by the aid of this invention the problem may be solved. From twenty-five to fifty feet of hose, attached at one end to the water supply, and fitted at the other with a ball nozzle, may be placed in every bath-room and kitchen, and, in the majority of cases, would serve to extinguish fires in private houses before much damage had occurred.

I have briefly described this invention and its most useful applications and have left the explanation of the phenomenon for final discussion. The problem connected with this invention may be put thus: Why does the ball adhere to the nozzle when there is behind it a force aggregating as high as hundreds of pounds pressure? The explanation usually given is that the atmospheric pressure holds the ball in its place and prevents it from falling or leaving the mouth of the nozzle. To this others answer that the pressure behind the ball far exceeds the atmospheric pressure; for instance, there is an exhibition given daily in New York with one of these nozzles where the water pressure equals 100 pounds per square inch, and as the atmospheric pressure is only about fifteen pounds, it would at first sight seem that the excess of pressure on the under side of the ball was eighty-five pounds, and ought, therefore, to expel the ball. The error, however, in this argument arises from failure to distinguish between the pressure of the water when confined in the pipes and when issuing around the ball. It is very certain that if 100 pounds pressure were acting directly upon the ball, it would be blown out of the nozzle, but it does not appear to me to act in this way. When the ball is confined to the mouth of the nozzle and pressed against it, it is undoubtedly subjected to the pressure of the water, but the moment it is raised slightly from the mouth, it is no longer subjected to this pressure, since the water is escaping all around it. In this respect it resembles the lid of a tea kettle when the water is boiling. By plugging the spout, the lid will be raised by the steam pressure sufficiently to allow the steam to escape at the sides. The explanation that seems to me

to be the correct one is as follows: The ball is acted upon by three forces: first, gravity; second, atmospheric pressure; and third, the force of the issuing stream. At first, the atmospheric pressure is the same at all points, and hence gravity has free play; but as soon as the stream passes through the nozzle, the atmospheric pressure from the under side is counteracted by the momentum of the issuing water, and the ball rising to a point where the water can pass freely around the sides, without pressing materially upon the ball, we have the full pressure of the atmosphere on the under half-side of the ball resisting the force of gravity. The ball, therefore, simply serves as a deflector to divert the current of water or to spread it out, and the resistance of the atmosphere against the ball suffices not only to perform this operation but also to sustain its weight.

It is possible that the density of the air may also be somewhat increased under the ball by the action of the spray. With a heavy pressure, the ball is further removed from the nozzle than with a light pressure. The same holds good respecting a heavy ball and a light ball. Most of these so-called paradoxes may be attributed to momentum or inertia. Take, for instance, the phenomenon of the injector. "If a 1-inch opening in a boiler, carrying 15 pounds pressure above the atmosphere, be made, if there is no reduction by friction, steam will issue from it at a velocity of about 1,440 feet per second, and the steam which would issue from it would be 10 cubic feet per second, which would weigh $\frac{3}{4}$ of a pound. When this steam is condensed to water, it maintains its velocity but is reduced in volume from 10 cubic feet to $\frac{1}{90}$ of a foot, or in other words, the stream of steam of 1-inch area, which issued at 1,440 feet per second, is reduced to a stream of water $\frac{1}{12}$ of an inch in diameter, having the same velocity—1,440 feet per second.

"The laws of hydraulics show that water will issue from a vessel under a pressure of fifteen pounds per square inch, with a velocity of forty-five feet per second, and that any stream having a greater velocity than forty-five feet per second, if directed against the orifice in the vessel, will enter it, notwithstanding the pressure inside the vessel.

The jet of condensed steam has a velocity of 1,440 feet per second, or more than thirty times that necessary to re-enter the boiler. This velocity is, therefore, reduced by mixing it with 900 times its weight in water, and this mixture will still enter the boiler."* This, of course, is merely theoretical and is largely reduced by friction; but in practice it is well known that steam will carry many times its own weight in water into a boiler from whence the steam is itself derived. We have, therefore, in the ball nozzle, the momentum of the moving stream of water which overcomes the atmospheric pressure on the under side of the ball, and the inertia of the ball which serves to keep it from moving, aided by the atmospheric pressure on its top side. This is my own explanation of a phenomenon which seems to puzzle a great many people, but which is strictly soluble by the well-known laws of physics.

In conclusion, I believe this invention, simple as it is, is destined to become a very great friend of society, particularly as a protection against the scourge and devastation of fire, and a means of saving human lives as well as very much of the wealth which annually disappears in smoke.

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HAVING THE LOGARITHMS OF TWO NUMBERS, TO FIND THE LOGARITHM OF THEIR SUM OR DIFFERENCE.

By NATHANIEL HILL.

For the solution of this problem, *addition* and *subtraction* logarithms were devised; Zech's seven-figure tables being published in the year 1849, and the five-figure tables of Gauss presumably quite as early, as his name is often used to identify this kind of logarithm. Newcomb's five-figure tables, Pierce's, Wheeler's and Macfarlane's four-figure tables are more recent, and are also American publications.

* Appleton's Cyclopædia.

Newcomb aptly says of these tables: "The problem can, of course, be solved by finding the numbers corresponding to the logarithms, adding or subtracting them, and taking out the logarithm of their sum or difference. The table under consideration enables the result to be obtained by an abbreviated process."

It is proposed here to show methods of solving the problem without other than the common logarithmic tables, which will compare favorably with the method by special tables, in respect of abbreviation, convenience and precision.

The use of seven-figure tables will first be explained: Take the difference of two given logarithms as the argument, and when this argument is 6·+, 5·+, or 4·+, take, respectively, the $\frac{1}{100}$ part, the $\frac{1}{10}$ part, or the whole tabled difference belonging to the tabled logarithm nearest to the argument, which add to the larger given logarithm for the logarithm of the sum, or subtract the same for the logarithm of the difference.

When the argument is 3·+, or 2·+, and the logarithm of the sum is required, take the difference between the tabled logarithm nearest to argument, and that logarithm, one line or ten lines below, and add to larger given logarithm; for the logarithm of the difference, take the difference between the nearest tabled logarithm and that, respectively, one line or ten lines above, and subtract from the larger given logarithm.

The principle involved cannot be applied to the remaining cases; that is, when argument is 1·+, or 0·+. The method applicable to these cases will be explained after the above *special method* is exemplified.

EXAMPLES.

1st Argument = (diff. (1) and (2).) . .	(3)	6·2439554
Given	(1)	7·8798411
"	(2)	1·6358857
Tabled diff., 248·	(4)	2
Add (4) and (1)	(5)	7·8798413 = *log. of sum.*
Sub. (4) from (1)	(5)	7·8798409 = *log. of diff.*

2d Argument = (diff. (1) and (2).)	(3)	5·2439554
Given	(1)	6·8798411
"	(2)	1·6358857
Tabled diff., 248·	(4)	25
Add (4) and (1)	(5)	6·8798436 = *log. of sum.*
Sub. (4) from (1)	(5)	6·8798386 = *log. of diff.*
3d Argument	(3)	4·2439554
Given	(1)	5·8798411
"	(2)	1·6358857
Tabled diff.	(4)	248
Add (4) and (1)	(5)	5·8798659 = *log. of sum.*
Sub. (4) from (1)	(5)	5·8798163 = *log. of diff.*

4th Argument	(3)	3·2439554	Nearest tabled log.	·2439553
Given	(1)	4·8798411	Log. on line below	·2442029
"	(2)	1·6358857	Diff. (4)	2476
	(4)	2476		
Add (4) and (1)	(5)	4·8800887 = *log. of sum.*		
	(1)	4·8798411	Log. nearest arg.	·2439553
	(4)	2477	Log. on line above	·2437076
			Diff. (4)	2477
Sub. (4) from (1)	(5)	4·8795934 = *log. of diff.*		
5th Argument	(3)	2·2439554	Nearest tabled log.	·2439553
Given	(1)	3·8798411	Log. 10 lines below	·2464247
"	(2)	1·6358857	Diff. (4)	24694
	(4)	24694		
Add (4) and (1)	(5)	3·8823105 = *log. of sum.*		
	(1)	3·8798411	Log. nearest arg.	·2439553
			Log. 10 lines above	·2414718
	(4)	24835	Diff. (4)	24835
		3·8773576 = *log. of diff.*		

A general method, applicable to all cases in all tables of logarithms, not as convenient, however, as that shown for the cases already given, now follows, and is to be used for arguments 1· + and 0· +, and sometimes, for argument 2· +.

Enter table with the difference of the given logarithms, and observe the number corresponding to argument, and, for the logarithm of the sum, take out the logarithm of a number one unit larger and add to the smaller given logarithm; for the logarithm of the difference, take out the

logarithm of a number one unit smaller and add to the smaller given logarithm.

6th Argument	(3)	2·2439554 = log.		175·37004
Given	(1)	3·8798411	Add . .	1
"	(2)	1·6358857		
Log. 176·37004	(4)	2·2464248		176·37004
Add (4) and (2)	(5)	3·8823105 = *log. of sum.*		
				175·37004
			Sub. . . .	1
			=	174·37004
	(2)	1·6358857		
Log. 174·37004	(4)	2·2414719		
Add (4) and (2)	(5)	3·8773576 = *log. of diff.*		
7th Argument	(3)	1·2439554 = log.		17·537004
Given	(1)	2·8798411	Add . . .	1
"	(2)	1·6358857		
Log. 18·537004	(4)	1·2680395		18·537004
Add (4) and (2)	(5)	2·9039252 = *log. of sum.*		
	(2)	1·6358857		
Log. 16·537004	(4)	1·2184568		
Add (4) and (2)	(5)	2·8543425 = *log. of diff.*		
8th Argument	(3)	·2439554 = log.		1·7537004
Given	(1)	1·8798411		
"	(2)	1·6358857		
Log. 2·7537004	(4)	·4399167		
	(5)	2·0758024 = *log. of sum.*		

It may be noted of the above cases that the second reference is conveniently made from the first; that is to say,

with argument 0· +, at same place on page 10, leaves forward or back.
" 1· +, " " " 1 leaf " "
" 2· +, " column 10 lines " "
" 3· +, " " 1 line " "
" 4· +, at adjoining logarithms.
" 5· +, and above, to same logarithm and proportional parts.

Two cases showing irregularity in the second reference are shown below:

Argument ·302—, and logarithm of difference required:

9th Argument	(3)	·2439554 = log.		1·7537004
	(1)	1·8798411	Sub. . . .	1
	(2)	1·6358857		·7537004
Log. ·7537004	(4)	9·8871957		
		1·5130844 = *log. of diff.*		

Argument more than ·954, and logarithm of sum required.

10th Argument	(3)	·9639554 = log.		9·20355
	(1)	1·8798411	Add . .	1
	(2)	·9158857		10·20355
Log. 10·20355	(4)	1·0087512		
	(5)	1·9246369 = *log. of sum.*		

The methods shown for arguments 2·+, and larger, apply to five, and four-figure tables, in the order following:

Seven-figure Tables.	*Five-figure Tables.*	*Four-figure Tables.*
That for Arg. 6·+	to Arg. 5·+	
" 5·+	" " 4·+	to Arg. 3·+
" 4·+	" " 3·+	" " 2·+
" 3·+	" " 2·+	" " 1·+
" 2·+	" " 1·+	

The methods for arguments larger than 2·, in seven-figure tables, and 1·, in five, and four-figure tables, may be expressed by this *special rule:*

Enter table with the difference of given logarithms, and, for logarithm of the sum, observe the difference between the tabled logarithm nearest to argument, and that of a number one unit greater than the number corresponding to the nearest tabled logarithm, and add this difference to greater given logarithm; for logarithm of difference, subtract the difference between the nearest tabled logarithm and that of a number one unit smaller, from the greater given logarithm.

The foundation of the general rule is

$$log.\,(a \pm b) = log.\,b\left(\frac{a}{b} \pm 1,\right)$$

and that of the special rule is

$$log.\, b\left(\frac{a}{b}+1\right) = log.\, a + log.\left(\frac{a}{b}+1\right) - log.\,\frac{a}{b},$$

and

$$log.\, b\left(\frac{a}{b}-1\right) = log.\, a - \left(log.\,\frac{a}{b} - log.\left(\frac{a}{b}-1\right)\right)$$

In all cases, $a > b$.

The application of these or other formulas to the solution of the stated problem, by means of the common logarithmic tables, is believed to be now for the first time presented.

LOWELL, MASS., June 1, 1895.

ELECTRICAL SECTION.

Stated Meeting of May 28, 1895.

MR. CARL HERING, President, in the Chair.

TEST OF AN ELECTRIC RAILWAY.

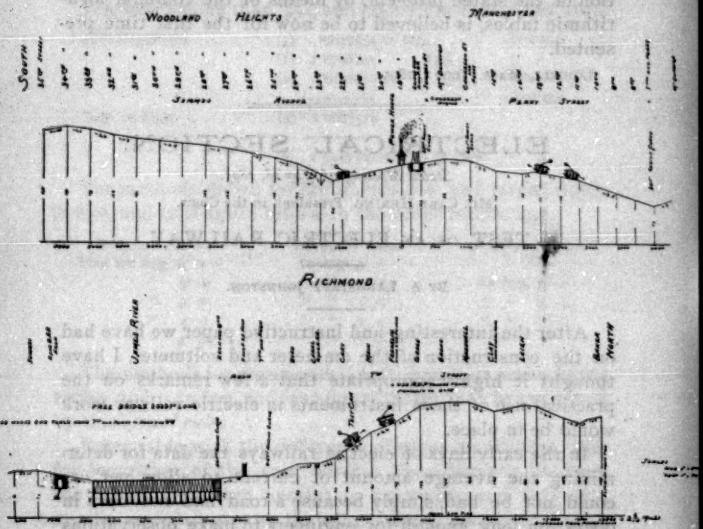
BY A. LANGSTAFF JOHNSTON.

After the interesting and instructive paper we have had on the construction of the ammeter and voltmeter, I have thought it highly appropriate that a few remarks on the practical use of these instruments in electric railway work would be in place.

In the early days of electric railways the data for determining the average amount of current to allow per car could not be had, simply because a road had not been in operation long enough for engineers to make observations on this point.

In 1890 I constructed a line which, for alignment, grades and local conditions, can be classed as a "difficult route," curves 30 feet radius on grades and in narrow streets, grades $7\frac{4}{10}$ per cent., and running over other roads. As the road was operated by one Edison 80 kilowatts generator, driven by one 100 horse-power Ball engine, the equipment consisted of five cars mounted with two 15 horse-power Sprague motors each; all these conditions made it highly favorable

for giving results of practical value. I made a series of tests, not only to determine this point, but the total amount of current leaving the power-house, when the cars were in the most unfavorable combination, *i. e.*, the majority ascending the grades. Although not as extensive and as accurate as I wished, yet I have considered them of sufficient interest to present to you. To accomplish this, on one of the cars



Profile of the Richmond and Southside Electric Railway, showing location of cars when test car No. 5 on maximum grade, by A. Langstaff Johnston, M. Am. Soc. C.E. Nov. 1, 1890.

was placed a Weston portable ammeter and voltmeter, on the other four cars were placed observers with time cards upon which they noted the time of passing previously marked points on the line, all watches being set with the clock at the power-house, where an observer took the reading of the station instruments.

The profile and table which you now have on the screen,

give the general data of one of the tests, and one when the test car was going over the road from the south to the north. The profile shows the location of the other four cars at the very instant the test car was on the centre of the maximum grade ($7\frac{4}{10}$ per cent.), and the table, the data taken on the car and in the power-house during the test.

A study of the table brings out some very interesting points—(1) The maximum amount of current (100 ampères) was at 6·05 P.M., when the test car was on a level and 6,500 feet from the power-house, and using the minimum amount of current (10 ampères). This was caused by the position of the other four cars, the time cards of the observers showing them either on the heavy grades or on the curves. (2) At 5.53 P.M., the test car used the maximum amount of current, and was also on a level and only 300 feet from the power-house; as should be expected, there was no drop in the voltage. It is also seen that the test car, in passing around the curves at Seventh and Perry Streets, Ninth and Arch Streets and Seventh and Arch Streets, took the same amount of current, but with a very large drop in the voltage (80 volts) at Seventh and Arch Streets. At first it was hard to explain this, but by a study of local conditions at this point, I discovered that the motorman had to shut off the current, and did not turn it on until he was in the centre of the curve, when he had to open it up to the seventh notch of the controller to force the car around this 40 feet radius curve, which readily accounts for the large drop that is shown. The same explanation applies to the curve at the Semmes Avenue Bridge; there the car had to cross a narrow bridge at a low speed, on a curve of 35 feet radius. (3) On the maximum grade of $7\frac{4}{10}$ per cent., which was 9,800 feet from the power-house, it took 40 ampères and 440 volts (which was forty volts drop on the line), or $23\frac{1}{2}$ electrical horse-power, to take the test car up the grade at the rate of four miles an hour. The profile shows the test car on this grade, and the location and the direction of travel of the other four cars at this very instant.

These tests show very conclusively the electrical economy that can be gained by a continuous-running motor, which

RECORD OF A TEST MADE OVER THE LINE OF THE RICHMOND AND SOUTHSIDE ELECTRIC RAILWAY, BY A. LANGSTAFF JOHNSTON, C. E., CHIEF ENGINEER, NOVEMBER 1, 1890.

Instruments placed on Car No. 5, and Car run over the East Track from the South End at Thirty-fourth Street and Semmes Avenue, Woodland Heights, to Seventh and Baker Streets, Richmond.

NORTH TRIP.

Time taken on Test Car. P.M.	Location of Car on Line.	Weight of Car and Passengers, Pounds estimated.	Rate of Grade per cent.	Length of Grade.	Distance of Test Car from Power House at time Readings were taken (Feet).	Kind of Rail passed over.	Reading of Meters on Car. Amperes.	Reading of Meters on Car. Volts.	Reading of Meters at Power House. Amperes.	Reading of Meters at Power House. Volts.	Horse-power delivered at Power House.	Horse-power developed by Motors in Moving Car.	Drop in Voltage on Line.	Radius of Inside Rail of Curve.	Remarks.
5.45	Thirty-fourth and Semmes Ave.	8,000	+ 1·5	310	5,500	T	20	460	60	480	38·6	12·3	20	—	Grades opposed to car going north, marked thus +
5.50	Semmes Ave. bet. power house and 22d St.	8,000	+ 2·3	1,000	1,000	T	20	460	80	480	51·5	12·3	20	—	
5-53	Curves at Semmes Ave. bridge	8,000	—	—	300	T	45	480	—	480	—	28·9	00	35′	
5-54	Curve at Cowardin and Perry	8,000	—	—	1,100	T	30	460	—	480	—	18·5	20	49′	Grades opposed to car going south, marked thus —
5-55	Fifteenth and Perry, Pass No. 2	8,200	—	—	1,500	T	—	—	80	480	51·5	—	20	38′	
6.	Curve at Perry and Seventh	8,200	—	—	4,400	T	40	460	20	480	12·9	24·6	20	38′	
6.01	On Seventh bet. Perry and McDonough	8,200	+ 3·	360	4,200	Tram.	30	480	—	—	—	19·3	00	—	Grades are given in feet per 100 (per cent. %).
6.03	South end free bridge, Pass No. 3	8,200	—	—	5,600	Tram.	—	—	—	—	—	—	—	—	
6.05	On free bridge	—	0·0	—	6,500	Tram.	10	445	100	480	64·3	5·9	35	—	
6.06	Curve at Ninth and Arch	—	—	—	7,700	Tram.	40	460	—	—	—	24·6	20	39′	Each car equipped with two 15 h. p. motors (Sprague).
—	Curve at Seventh and Arch	—	—	—	8,500	Tram.	40	400	—	—	—	21·4	80	40′	
—	Seventh between Arch and Byrd	—	+ 5·2	300	8,700	Small grove.	20	440	—	—	—	11·7	40	—	
6.10	Seventh between Main and Cary	—	+ 7·4	300	9,800	Small grove.	40	440	90	480	57·9	23·5	40	—	Maximum grade.
—	Seventh between Franklin and Main	—	+ 2·0	300	10,400	Small grove.	15	444	—	—	—	8·9	36	—	
—	Seventh between Franklin and Grace	8,000	+ 6·9	300	10,800	Tram R.U.P.	25	400	—	—	—	13·4	80	—	Richmond Union Pass Track.
6.15	Seventh and Marshall	8,000	—	—	11,700	Tram R.U.P.	—	440	80	480	51·5	—	40	—	
—	Seventh between Clay and Leigh	8,000	+ 1·7	400	12,400	Tram.	20	420	—	—	—	11·2	60	—	

a great many attempts have been made to put in practical operation, but so far without success, and is a line on which inventors can work and experiment in the hope of a large reward, if successful; for it is evident, with a continuous revolving armature there would be only a small drop in the counter E. M. F., whereas, now, every time the motor is started it has to build up, and particularly in cities where the regulations require the cars to come to a full stop at each street crossing, the distances between stops are so short that the armature is revolving at a velocity to be of very little effect for only a few seconds, and really amounts to nothing.

From the profile and table the members of the Section can readily see many other interesting points, but the most important one shown by this test is the necessity of the electrical engineer to study the local conditions in proportioning the feed system of an electric railway, making use of the data given him of former work by his volt- and ampère-meters.

CHEMICAL SECTION.

Stated Meeting of May 21, 1895.

DR. W. C. DAY, President, in the Chair.

[The President announced the paper for the evening, and introduced the speaker.]

THE CITRATE METHOD OF PHOSPHORIC ACID DETERMINATION, WITH SPECIAL REFERENCE TO INSOLUBLE PHOSPHATES.

BY F. BERGAMI.

The molybdate method of phosphoric acid determination has always been regarded as a very safe and accurate method, and its general applicability surely imparts to it an inestimable value as a gravimetric method.

Although some doubts have lately arisen as to its absolute infallibility, for some not yet fully explained reasons,

the only objection usually made to this method is the slow process of its execution.

The chemists of the iron and steel industry, as well as the agricultural chemists, for many years have been looking for a more rapid and still exact method. Of all the propositions made in this regard, those recommending the titration of the molybdate precipitate, either directly by standard alkali, or, after previous reduction by permanganate of potash, have found the most advocates and adherents.

The apparently good results obtained by a method founded on this principle, and which was described in 1893 by Mr. H. Pemberton, Jr., in a paper read before this Section, had induced Dr. B. W. Kilgore, the reporter of the Association of Official Agricultural Chemists of the United States to submit this method in its original form, as well as in a modification recommended by Dr. Kilgore, for investigation to all the chemists who took part in the yearly research of the Association in 1894. The reported results, although not entirely satisfactory, were sufficiently promising to warrant giving the method another trial during the present year.

While this has been the only attempt of the American official chemists to shorten the way of phosphoric acid determination, we find, in looking over the reports of the conventions of the German Agricultural Chemists, that they have successfully solved this problem in a different direction.

Since the abandonment of the old uranium titration method, the German chemists seem to have lost faith in volumetric phosphoric acid determination, and have, therefore, after careful trial, adopted a gravimetric method, based upon the principle that magnesium-ammonium phosphate can be directly precipitated from calcium phosphate solutions, practically free from impurities, if a sufficient quantity of citric acid is present in the solution. This method is now universally used in Germany, and the molybdate method is now only obligatory in cases of arbitration.

The literature accessible to me shows only confirmatory figures of tests made on water-soluble phosphoric acid, and

none in regard to insoluble phosphates. The reports of the conventions of official chemists of the United States mention the citrate method repeatedly, but I have been unable to find in them any record that it has ever been given a practical trial. Those two facts are responsible for the following investigation:

Before starting the investigation, it had first to be decided what was the best way of bringing the phosphates into solution.

Some chemists recommend solution in nitric and hydrochloric acids, while others use sulphuric acid with a small amount of nitric acid. The latter affirm that the method gives better results, if the larger portion of calcium oxide is removed as calcium sulphate, and thus the amount of calcium oxide still left in the solution is made a constant one in all samples. This presumption seems to have a very good foundation, especially in cases of high-grade phosphates with large amounts of calcium oxide. I decided, nevertheless, on solution in nitric and hydrochloric acids, for two reasons: (1) because those acids are used chiefly as solvents for phosphates in our laboratory; and (2) because I thought it interesting to test the method under the most unfavorable circumstances. Therefore, the solution of all samples used in this investigation was effected by boiling 2 grams of the substance with 40 c.c. of concentrated nitric acid and 10 c.c. of hydrochloric acid, and subsequent dilution to 250 c.c.

The citrate solution was prepared strictly according to Prof. Maerker's direction, viz.: 150 grams citric acid are dissolved in water, 500 c.c. of 24 per cent. ammonia added, and the whole brought to a volume of 1,500 c.c. by water.

The first three samples subjected to tests were a refuse bone-black, a bone meal, and a South Carolina phosphate.

Two grams were dissolved in the manner above stated, and the phosphoric acid was determined by the molybdate method.

Aliquot portions, corresponding to 0·2 and 0·4 gram of substance, were mixed with 25 c.c., 50 c.c., 75 c.c. and 100 c.c. of citrate solution, respectively, and, where necessary, suffi-

cient quantities of ammonia added, to provide for about the same alkaline reaction in all cases. After the addition of 25 c.c. of official magnesia mixture, the complete precipitation of magnesium-ammonium phosphate was effected by vigorous stirring with a glass rod for a half an hour, and the precipitate was treated in the usual way.

The results obtained are as follows:

I. REFUSE BONE BLACK, NO. I.

Molybdate Method.

	Per Cent.	Difference.
25 c.c. corresponding to 0·20 gram	35·68	
50 c.c. " 0·40 "	35·68	

Citrate Method.

25 c.c. corresponding to 0·20 gram, 25 c.c. citrate solution	36·00	+ ·32
25 c.c. " 0·20 " 50 c.c. " "	35·74	+ ·06
25 c.c. " 0·20 " 75 c.c. " "	35·68	
25 c.c. " 0·20 " 100 c.c. " "	35·52	— ·16
50 c.c. " 0·40 " 50 c.c. " "	36·08	+ ·40
50 c.c. " 0·40 " 75 c.c. " "	35·76	+ ·08
50 c.c. " 0·40 " 100 c.c. " "	35·60	— ·08

II. BONE MEAL, NO. I.

Molybdate Method.

	Per Cent.	Difference.
25 c.c. corresponding to 0·20 gram	22·40	

Citrate Method.

25 c.c. corresponding to 0·20 gram, 25 c.c. citrate solution	22·56	+ ·16
25 c.c. " 0·20 " 50 c.c. " "	22·40	
25 c.c. " 0·20 " 75 c.c. " "	22·24	— ·16
25 c.c. " 0·20 " 100 c.c. " "	22·24	
50 c.c. " 0·40 " 50 c.c. " "	22·64	+ ·24
50 c.c. " 0·40 " 75 c.c. " "	22·40	
50 c.c. " 0·40 " 100 c.c. " "	22·32	— ·08

III. SOUTH CAROLINA ROCK.

Molybdate Method.

	Per Cent.	Difference.
25 c.c. corresponding to 0·20 gram	26·56	

Citrate Method.

25 c.c. corresponding to 0·20 gram, 25 c.c. citrate solution	27·04	+ ·48
25 c.c. " 0·20 " 50 c.c. " "	26·72	+ ·16
25 c.c. " 0·20 " 75 c.c. " "	26·56	
25 c.c. " 0·20 " 100 c.c. " "	26·24	— ·32
50 c.c. " 0·40 " 50 c.c. " "	26·95	+ ·40
50 c.c. " 0·40 " 75 c.c. " "	26·64	+ ·08
50 c.c. " 0·40 " 100 c.c. " "	26·56	

The results show that the success of the method depends chiefly on the amount of citrate solution brought into action upon the phosphate. If the amount falls below a certain limit, the results become considerably too high, while a large excess of citrate solution tends to render the results a little too low. The high figures are undoubtedly due to a contamination of the magnesium-ammonium phosphate, and the low figures must be caused by incomplete precipitation.

Some chemists are of the opinion, that the co-precipitation of some SiO_2, CaO and possibly Fe_2O_3 and Al_2O_3, can never be prevented, while at the same time the dissolving action of the citric acid upon those oxides is always somewhat extended to the ammonium-magnesium phosphate also, and causes incomplete precipitation. The best results are obtained when the quantity of the citrate solution is such that the error through contamination is just compensated by the error through incomplete precipitation.

Other chemists assert that a sufficient quantity of citrate solution will prevent any contamination of the precipitate, and claim that the best results are obtained by an amount of citrate solution just large enough to keep all impurities in solution, and still not too large to exert any dissolving influence upon the precipitate, which, in such case should consist of pure magnesium-ammonium phosphate.

Here is a disagreement, and while it may be very interesting and even necessary, for scientific reasons, to know the real sources of error, it is immaterial for the practical applicability of the method, if only that certain amount of citrate solution can be ascertained which will secure good or at least approximately good results. A close observation of the above-stated figures reveals the fact that, with phosphates containing about from twenty to thirty-five per cent. phosphoric acid, results by the citrate method agree very well with those by the molybdate method, when from 50 to 75 c.c. of citrate solution are employed on 0·2 gram of substance, or from 75 to 100 c.c. on 0·4 gram.

The tests were now continued on some superphosphates and ammoniated superphosphates, with the following results:

AMMONIATED PHOSPHATE, NO. 1.

	Per Cent.
Molybdate Method	11·68
Citrate Method:	
50 c.c. corresponding to 0·40 gram, 50 c.c. citrate solution	11·76
50 c.c. " 0·40 " 75 c.c. " "	11·68
50 c.c. " 0·40 " 100 c.c. " "	11·52

AMMONIATED PHOSPHATE, NO. 2.

Molybdate Method	11·28
Citrate Method:	
50 c.c. corresponding to 0·40 gram, 50 c.c. citrate solution	11·28
50 c.c. " 0·40 " 75 c.c. " "	11·12
50 c.c. " 0·40 " 100 c.c. " "	11·04

ACIDULATED SOUTH CAROLINA ROCK.

Molybdate Method	15·84
Citrate Method:	
50 c.c. corresponding to 0·40 gram, 50 c.c. citrate solution	15·92
50 c.c. " 0·40 " 75 c.c. " "	15·76
50 c.c. " 0·40 " 100 c.c. " "	15·68

PURE DISSOLVED BONE.

Molybdate Method	16·80
Citrate Method:	
50 c.c. corresponding to 0·40 gram, 50 c.c. citrate solution	16·88
50 c.c. " 0·40 " 75 c.c. " "	16·72

Those tests on phosphates containing less than twenty per cent. of phosphoric acid indicate that an amount of 50 c.c. to 75 c.c. of citrate solution used on 0·4 gram of substance is the most favorable to the accuracy of the method.

Taking these results, together with those obtained on phosphates containing more than 20 per cent. phosphoric acid, we must conclude that an average amount of 75 c.c. of citrate solution acting on 0·4 gram of substance will give very good results on phosphates of all grades.

In all tests made so far, the average difference from the molybdate method does not exceed ± 0·10 per cent., when 0·40 gram of substance and 75 c.c. of citrate solution are used. The only case in which I fear the — difference may grow a little higher, is that in which the amount of phosphoric acid falls considerably below 10 per cent.; for instance, down to 5 per cent. or 4 per cent.; but as such a small percentage of total phosphoric acid is a comparatively rare occurrence, it may at present be neglected.

It will be shown later, by tests on citrate-insoluble phosphoric acid, that in cases where only a small amount of phosphoric acid is present a reduction of the quantity of citrate solution is necessary. The investigation on total phosphoric acid was previously ended with the following tests:

REFUSE BLACK, NO. 2.

				Per Cent.
25 c.c. corresponding to	0·20	gram,	molybdate method	29·60
25 c.c. "	0·20	"	50 c.c. citrate solution	29·60

BONE MEAL, NO. 2.

				Per Cent.
25 c.c. corresponding to	0·20	gram,	molybdate method	21·76
25 c.c. "	0·20	"	50 c.c. citrate solution	21·85

FLORIDA PHOSPHATE.

				Per Cent.
25 c.c. corresponding to	0·20	gram,	molybdate method	32·32
25 c.c. "	0·20	"	50 cc. citrate solution	32·48

EXPORT BONE.

				Per Cent.
50 c.c. corresponding to	0·40	gram,	molybdate method	12·64
50 c.c. "	0·40	"	50 c.c. citrate solution	12·64

AMMONIATED PHOSPHATE, NO. 3.

				Per Cent.
50 c.c. corresponding to	0·40	gram,	molybdate method	11·92
50 c.c. "	0·40	"	50 c.c. citrate solution	12·00

AMMONIATED PHOSPHATE, NO. 4.

				Per Cent.
50 c.c. corresponding to	0·40	gram,	molybdate method	11·76
50 c.c. "	0·40	"	50 c.c. citrate solution	11·76
50 c.c. "	0·40	"	100 c.c. citrate solution	11·60

ACIDULATED SOUTH CAROLINA ROCK, NO. 2.

				Per Cent.
50 c.c. corresponding to	0·40	gram,	molybdate method	16·00
50 c.c. "	0·40	"	50 c.c. citrate solution	16·08

ACIDULATED SOUTH CAROLINA ROCK, NO. 3.

				Per Cent.
50 c.c. corresponding to	0·40	gram,	molybdate method	16·32
50 c.c. "	0·40	"	75 c.c. citrate solution	16·24

The last line of tests shows that the method, under certain circumstances, allows of a little modification. For instance, the analyst who has to control the manufacture of fertilizers generally knows the approximate amount of phosphoric acid contained in the product which he has to examine. He may, therefore, when working on

high-grade phosphates, prefer to use only 50 c.c. of citrate solution on 0·2 gram of substance, instead of the average amount of 75 c.c. on 0·4 gram of substance. The reason why I consider it an advantage to employ only so small a portion as 0·2 gram is that in some dark-colored phosphate solutions a little organic matter is thrown down together with the magnesium precipitate.

In such a case it takes much longer to burn the precipitate to perfect whiteness, when the latter forms a larger bulk, for instance of 0·25 gram, than when it amounts to only one-half of this volume.

Solution in sulphuric acid and some nitric acid, as recommended by many chemists, may render my objection to the use of 0·4 gram of substance unnecessary, as it will very likely produce a more perfect oxidation of the organic matter, and a nearly colorless solution. Besides this, it removes a large part of the calcium oxide, which will probably lessen the source of error. I intend to make tests in this regard in the near future.

Wherever the percentage of the phosphate is known not to exceed 16, an amount of 50 c.c. citrate solution to 0·4 gram of substance seems to be sufficient, and may, especially where the phosphoric acid falls considerably below 10 per cent., be preferable to the employment of 75 c.c., as it would tend to reduce the error arising from incomplete precipitation.

No experiments were made by the writer in regard to the amount of magnesia mixture. The German practice is to use 25 c.c. in all cases, and this rule was strictly followed. A large excess of magnesia mixture seems to be necessary to neutralize the dissolving influence of the citrate solution upon the ammonium-magnesium phosphate. O. Reitmair (*Zeitschrift fuer angew. Chemie*, 1889, 702) supposes that a soluble double compound $Mg.NH_4.PO_4.(NH_4)_3.C_6H_5O_7$ is formed, which can only be decomposed if more magnesium chloride is present than can combine with the ammonium citrate to form $Mg.NH_4.C_6H_5O_7$.

The results, in respect of total phosphoric acid, had been so satisfactory that I hardly doubted that the method would

work just as well on the citrate-insoluble phosphoric acid. How far my expectations were substantiated will be shown by some tests, which were conducted in the following manner: 2 grams of an acidulated phosphate were treated with water and neutral citrate of ammonia solution, according to the official method; the residue and filter dissolved in 40 c.c. of nitric acid, and 10 c.c. of hydrochloric acid, and the solution brought to a volume of 200 c.c. In 50 c.c., corresponding to 0·5 gram of the original substance, the phosphoric acid was determined by the molybdate method. Another portion of 50 c.c. was mixed with 40 c.c. of citrate solution and made strongly alkaline by 20 c.c. of ammonia, sp. gr. 0·90. After the addition of 20 c.c. of magnesia mixture, the precipitation of ammonium-magnesium phosphate was effected by stirring for one-half hour. The filtration was executed after the lapse of different periods of time, as specified in the following table:

	Molybdate Method.	Citrate Method. *Filtration immediately after stirring.*	Citrate Method. *Filtration after 2 hours' standing.*
	Per cent.	*Per cent.*	*Per cent.*
Ammoniated phosphate, No. 1 . .	2·94	2·81	2·88
" " " 2 . .	2·17	1·98	2·04
" " " 3 . .	4·73	4·60	4·60
" " " 4 . .	3·20	3·00	3·13
		Filtration after 2 hours' standing.	
Ammoniated phosphate, No. 5 . .	4·41	4·35	
" " " 6 . .	3·32	3·32	
Acidulated bone	2·17	2·11	
		Filtration after 24 hours' standing.	
Acidulated bone	4·22	4·22	
Ammoniated phosphate, No. 7 . .	4·09	3·96	
Acidulated South Carolina rock, .	3·52	3·45	
" " " " .	1·40	1·28	

In the above tests, 40 c.c. citrate solution were used. In the following tests, this quantity was reduced to 25 c.c.:

	Molybdate Method.	Citrate Method. *Filtration after 2 hours' standing.*
	Per cent.	*Per cent.*
Ammoniated phosphate, No. 8	3·58	3·64
" " " 9	3·90	3·96
Acidulated South Carolina rock	1·40	1·34

In the determination of such small amounts of phosphoric acid it seems to be advisable to give the precipitate a little more time for development than in case of the total phosphoric acid, where it does not make any difference whether the precipitate is filtered at once after the stirring or at any later time. Two hours seem to be enough for this purpose, as the results after twenty-four hours fail to show any better agreement.

It appears that an amount of 40 c.c of citrate solution is still a little too large. The average of the results is a little lower than those by the molybdate method, and none of them are any higher. With a reduction of the citrate solution to 25 c.c., the results seem to get a little higher than by the molybdate method.

I believe that the most favorable proportion between substance and citrate solution will be 100 c.c., corresponding to 1 gram of the original substance and 50 c.c. of citrate solution.

I have not yet made any tests to confirm this supposition, as lack of time has prevented me at present from taking into consideration every possibility of modification and application of the method. For instance, another point of interest, which was not touched by this investigation, is the determination of extremely small amounts of phosphoric acid. The citrate-insoluble residue of some superphosphates, especially of those made from refuse bone-black, frequently contains no more than 0·1 to 0·3 per cent. of phosphoric acid, and it is very likely that in the determination of such small amounts the citrate method will prove to be a failure unless the quantities of substance and of the neutral citrate solution for extraction, as directed by the official method, are raised considerably.

In conclusion, I wish to make a few remarks in regard to the execution of the method.

The citrate solution exerts a somewhat retarding influence upon the precipitation, which must be overcome by stirring, to insure complete precipitation within a reasonably short time.

The German usage is to stir for one-half hour, and I believe that this length of time should never be shortened, for safety's sake. The errors to which an insufficient stirring can lead may be illustrated by the following test, viz.: 25 c.c. (= 0·2 gram of substance of the bone meal, No. 1), after adding 100 c.c. of citrate solution and 25 c.c. of magnesia mixture, were stirred only until the precipitate had appeared (about two minutes), and the latter filtered after the lapse of one-half hour.

The result was 21·12 per cent., as compared with 22·24 per cent., obtained by vigorous stirring for one-half hour. Of course, the proportion of 100 c.c. of citrate solution to 0·2 gram of substance was an extreme one, and I believe that wherever an amount of 75 c.c. is used on 0·4 gram of substance, the danger of incomplete precipitation is not quite so great, but it still exists.

The determination of citrate-insoluble phosphoric acid will be rendered absolutely unreliable by insufficient stirring, unless the precipitate is allowed to stand a long time before filtration.

Many propositions have been made to shorten the time of stirring—for instance, by the use of a feather with the barbs cut short, instead of a glass rod, or by adding some pulp of ashless filter paper, etc.—but as I have not tried any of them, I cannot judge of their reliability.

The objection has been made to the use of a glass rod that, as it is impossible to avoid coming in contact with the wall of the beaker, some portion of the precipitate will adhere firmly to the glass and can only be removed with difficulty. I must state that I never had any trouble in transferring the last traces to the filter by using a rubber-tipped glass rod for removing the adhering parts of the precipitate from the glass. In routine work the stirring must certainly be done by mechanical means.

While it may appear unnecessary and even ridiculous to dwell at length upon so simple an operation as the filtration of a precipitate, I can nevertheless not refrain from passing some remarks on this subject, for the reason that the filtration of the ammonium-magnesium precipitate is the only operation of the method which may cause some difficulty.

This precipitate, as obtained in presence of citric acid, is in a very fine form and has a strong tendency to pass through the filter. Therefore, great care must be taken in constructing a good filtering medium when a suction pump is used.

If the filtration be executed without pressure, it will be found necessary to employ two Schleicher & Schuell filter papers.

With the use of such a double filter I have not experienced any trouble in obtaining crystal-clear filtrates.

While on some voluminous precipitates, as, for instance, the molybdate precipitate, the loss, indicated by a slight turbidity of the filtrate and wash water, will not involve any appreciable error and may be neglected, such an inaccuracy should not be tolerated in the execution of the citrate method. Here the precipitate is in so compact a condition, even more than when obtained by the molybdate method, that a loss, which, by judging the turbidity of the filtrate, appears very small, may prove to be of serious consequence.

Wherever a large number of analyses is being carried on at once and no special attention paid to each single determination, the danger is great, that, for the reason just stated, losses of 0·10 per cent. to 0·20 per cent., and even more, may occur.

The sometimes enormous differences which appear in comparing the results of different analysts by methods considered most accurate and trustworthy by all leading chemists, must arouse the suspicion that the same are at least partly due to some neglect in the execution of such minor operations as, for instance, the filtration and washing of a precipitate.

This investigation is not presented as an exhaustive one. The tests are not numerous enough and not carried out systematically enough to allow a decisive judgment to be passed upon the method.

The samples analysed represent only phosphates of nearly the same character. The amount of SiO_2, Fe_2O_3 and Al_2O_3 present in most of them is extremely minute, and, even in the sample of South Carolina rock, comparatively small. Therefore, the tests will have to be extended to phosphates containing those and other bodies, which might possibly influence the method when present in larger quantities. It will further be of interest to find out if the use of sulphuric acid and some nitric acid, as solvents, would be of any considerable advantage.

The comparison of the citrate method with the molybdate method was made under the supposition that the results by the latter were correct. It has long been suspected, and the last year's investigation of the molybdate method by the Association of Official Agricultural Chemists of the United States, indicates strongly that the results by this method in its present form are a little too high. The plan submitted for this year's work of the Association, by Dr. B. W. Kilgore, will probably produce a sure proof of this error. In such case the results of the citrate method obtained by the action of 75 c.c. of citrate solution on 0·40 gram of substance would be too high also, and an increase of the quantity of citrate solution would probably be advisable.

The only possible way to secure a working plan of the citrate method, which would give general satisfaction, is by the coöperation of a larger number of American chemists. The hope of giving an impulse to such coöperative work, was the sole object of this investigation, which may be nothing more than a repetition of work done by others long ago.

It can hardly be expected that the citrate method, in the extremely simple form used for the tests above, will ever give absolutely correct results. The employment of the same quantity of citrate solution on all kinds of phosphates

with a widely varying percentage of phosphoric acid, will always tend to give results a little higher on high-grade phosphates and on those containing larger amounts of SiO_2, CaO, etc., than on low-grade phosphates and those with less impurities.

Still, as long as as it can be proven that with ordinary care the errors can be kept inside of limits which allow the use of the method for nearly all practical purposes, I do not see any reason why the same should not be given a place alongside of them olybdate method,especially under the consideration of the great discrepancies in the results of the latter method, obtained by different chemists on the same sample.

NOTES AND COMMENTS.*

THE NEW CANADIAN "SOO" CANAL.

In the Secretary's annual report, printed in the *Journal* for February, reference was made to the enterprise of the Dominion authorities in endeavoring to secure for that country a complete chain of navigable waterways connecting the great lakes with the ocean, on Canadian territory. The last link in this chain has been supplied by the completion of the Canadian "Soo" Canal, which was formally opened for traffic on June 13th.

The following reference to the subject from *The Press*, of Philadelphia, treats of it in an interesting way:

The new Canadian canal around the Falls of the River St. Mary, which joins Lakes Superior and Huron, will be opened to-day, and another one of the enterprises which mark the closing years of the nineteenth century will be practically finished. This is the canal the British Government has been building for some years past so as to give it an independent route from the Atlantic Ocean to the upper lakes. It has been cut through St. Mary's Island, on the Canadian side of the St. Mary's River Rapids, for 3,500 feet, the whole canal being 18,100 feet long, 152 feet wide at the surface, 145 feet wide at the bottom and with a navigable depth of at least twenty feet. The lock is 900 feet long, sixty feet wide and twenty-two feet deep, and will accommodate three vessels at once.

This canal is entirely distinct from the canal the United States Government is building on the Michigan side of the St. Mary's Falls. The latter will not be completed for a year yet, but in some respects it will be more commodious than the Canadian canal. The lock in the American canal now in use is only 515 feet long, eighty feet wide and twenty-one feet deep, but

* From the Secretary's monthly reports.

the new lock which will be finished soon will have a length of 800 feet, a breadth of 100 feet and a depth of twenty-one feet, and it will be able to accommodate four vessels at one time. This, with the construction of the channel 300 feet wide and twenty feet deep, below the Falls, and which will save a distance of eleven miles, will make the most complete passage-way between Lakes Huron and Superior. The British canal has cost about $5,000,000, while the cost of the American canal is estimated at $4,740,000.

The different methods employed by the American and British Governments when a great public improvement is demanded are well illustrated in the building of these two canals around the rapids of St. Mary's River. The British canal was begun and finished in about five years, but the American canal was begun nearly fifty years ago and patching has been going on ever since. In the meanwhile commerce by this route has been vastly increased until the tonnage passing through the Sault Ste. Marie locks greatly exceeds the tonnage of the Suez Canal, notwithstanding the fact that the latter is open all the year and the former an average of about 250 days in the year. During last season 10,208 steamers and 3,676 sail vessels carrying 13,110,366 registered tons of freight passed through the canal. This was an increase of more than 3,000,000 tons over the previous season. The cost of moving freight through the canal last year was less than 1 cent per ton per mile.

With the opening to-day of the new canal around the Falls of the St. Mary's River the Dominion will have an uninterrupted route from the western end of Lake Superior to the Atlantic Ocean. The only way the United States can match this enterprise is by enlarging and deepening the Erie Canal through New York State.

AN APPARENTLY NEW OBSERVATION IN ELECTROLYSIS.

E. Andréoli, in a recent impression of *Le Génie Civil*, gives a brief description of an interesting and apparently new phenomenon in electrolysis, and which he has utilised in effecting the electrolytic deposition of metals and the decomposition of salts. He defines the method by the term "indirect electrolysis."

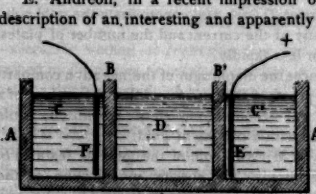


FIG. 1.

The nature of the phenomenon alluded to will be made apparent by the following description, viz.:

Assume that the central compartment *D*, of a chamber *A*, divided into three parts by two porous partitions *B B'* (*Fig. 1*), be filled with a (conducting) solution of any kind, while the lateral compartments *C C'*, have an anode *E* and a cathode *F*, immersed respectively in an electrolyte, which may be the same in both, or different in each. Under these conditions electrolysis in *C C'* proceeds the same as if the central compartment were absent, the solution in this compartment remaining unaffected by the electrolytic

action taking place in the two lateral compartments. It undergoes no change, but, on the contrary, remains inert, notwithstanding the decomposition of the anolyte and catholyte, respectively, in the adjacent lateral compartments. But if a metallic plate, or several of them, be introduced in the solution of the central compartment *D* (*Fig. 2*), electrolytic action at once begins.

M. Andréoli believes that he has been the first to observe and utilise this phenomenon, which he defines as "indirect or secondary electrolysis."

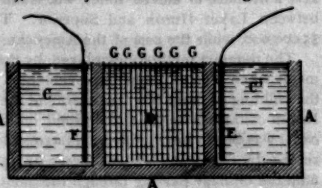


FIG. 2.

The following example will serve to illustrate the method in practice:

Let it be assumed that the compartments *C C*, on the right and left, are supplied with a solution of common salt, and that the middle one contains a solution (either concentrated or dilute) of cyanide of gold. On the positive side, *C'*, there is an anode of retort carbon, and on the other, *C*, a cathode of iron.

As soon as the current is established in the vessel *A*, electrolytic decomposition takes place, with the liberation of chlorine at the positive electrode *E*, and of caustic soda at the negative electrode *F*, and the solution of cyanide of gold in *D* is not affected by the migration of the ions.

If, however, a metal plate, or, preferably, a number of such plates, *G G G G G*, be immersed in the solution of the central compartment, there will take place a deposition of gold upon these plates, notwithstanding that they are not connected with either the positive or the negative pole of the generator of electricity, or with the anode or the cathode in the adjacent compartments. Neither chlorine from the compartment *C* nor soda from the compartment *C'* will enter the central compartment *D* (*sic*), and contaminate the gold solu- which last, according to the density of the current and the number of plates, will be exhausted of gold more or less rapidly.

The section of liquid which faces the diaphragm of the negative compartment should be positive, and, in proof of this, it is found that the surface of a lead plate facing this diaphragm will become completely peroxidized, while the other side will become covered with a coating of gold.

Such is the description given by M. Andréoli, of the general features of the operation of "indirect electrolysis." The specific modification of the foregoing experiment, given in what immediately follows, is equally novel and interesting, and (assuming the facts to be correctly reported) more difficult of satisfactory explanation, viz.:

Says the author: "I have replaced the salt solution of the positive and negative compartments *C C'* with a solution of cyanide of gold identical with that in the central compartment *D*. The anode was a plate of lead, the cathode one of iron. After the lapse of several days, I removed 100 c.c. of the solution from the lateral compartments, which I evaporated to dryness, then collected, scarified and cupelled the residue, and was able to confirm

the fact that the quantity of gold obtained was absolutely the same as that found in 100 c.c. of solution of gold before treatment. On the cathode there was not a trace of gold, consequently there was no such deposition of gold as takes place in the ordinary galvanoplastic operations; whereas, during the period of the experiment, I have been able practically to exhaust of its metal 100 liters of the gold solution in the central compartment."

Although it is not stated in terms that the electrolyte in this experiment was acted upon, during the several days spoken of, by a current from an external source of electricity, the context would seem to make this assumption necessary. How it comes to pass that the electrolyte in the lateral chambers in which anode and cathode are immersed suffers no decomposition, while that in the central chamber, which is quite independent of metallic connection with either anode or cathode, or with the source of current, is not clear. The difficulty is not lessened if it be assumed that the installation of the lateral cells acted as a primary battery.

M. Andréoli proceeds to describe other examples of his method of "indirect electrolysis." One of these, which may possibly find practical application, relates to the decomposition of bisulphite of sodium for the production of nascent hyposulphurous acid for bleaching purposes. The decomposition of the sulphites and bisulphites, by the ordinary electrolytic methods is impracticable. but, according to M. Andréoli, it is accomplished by the indirect method with ease and rapidity. For the details of this particular procedure, the reader is referred to the original source (*vide Le Genie Civil*, July, 1895, p. 137).

The facts observed and ingeniously utilised by this author appear to be novel. While apparently anomalous, they will doubtless prove to be susceptible of satisfactory explanation without doing violence to accepted explanations of electrolytic phenomena. W.

TECHNICAL NOTES.

Gesner's method of *protecting iron and steel against rust*, which is described in *La Revue Scientifique* consists in forming on the surface of the metal a double carbide of hydrogen and iron, which is extremely hard and adherent. In fact, a bar thus coated can be bent through an angle of forty-five degrees without disturbing the layer. In carrying out the process, the articles are thoroughly cleaned from rust, but it is not indispensable to remove all oil or grease. A couple of gas retorts are placed alongside each other, and raised to a temperature of from 600° C. to 700° C. The articles to be treated are then placed in these retorts for about twenty minutes, after which a current of hydrogen is passed through the retorts for forty-five minutes. A small quantity of naphtha is then introduced, the supply being maintained for ten minutes. It is then stopped, the current of hydrogen being kept up fifteeen minutes longer, when it is stopped and the retorts allowed to cool to 400° C., and when this temperature is reached the doors can be opened and the finished product removed. The coating thus given has a bluish color.

In some recent tests of the Marsden *cornstalk cellulose* and English cocoa

cellulose, made at Indian Head proving grounds, the results were in favor of the former. The Marsden material is made of the pith of cornstalks. It was made into a cofferdam and shipped to the proving grounds. A cofferdam of the English product was also made and it was sent to the proving grounds. There the two were set up side by side, and a six-inch and an eight-inch shell fired into each. The interior of the dams was then filled with water, and it was found that both practically held all the liquid. After a short time, however, a few drops of water were seen to trickle through the cocoa cellulose, but none penetrated the cornstalk product.

An artificial rubber of more or less strength may be obtained by dissolving four parts of nitro-cellulose in seven parts of bromo-nitro-toluol. Upon varying the proportion of the nitro-cellulose, there may be obtained a material possessing elastic properties and much resembling india-rubber, and even gutta-percha. Nitro-cumol and its homologues may, if desired, be used instead of bromo-nitro-toluol. *Invention* describes another substitute for india-rubber lately discovered by E. Desprez, of Paris. Gutta-percha, in the form of sheet, is taken and covered on one or both sides with a close-meshed fabric—even wire gauze will serve for some purposes—and the whole is agglomerated by pressure under heat. Sawdust, zinc dust and other suitable and cheap materials may, it is understood, be incorporated with the gutta-percha.—*Phar. Jour.*

A composite steam pipe, which, its designer claims, meets the requirements of increasing pressures, and at the same time possesses the advantages of a copper pipe, has been patented by Mr. R. D. Smillie, electrical engineer, Glasgow. As described in the *Engineering and Mining Journal*, it consists of a shell of copper of sufficient strength to withstand the longitudinal stresses produced by any given pressure of steam acting on the sectional area of the pipe. The circumferential stresses are provided for by a coil of steel wire, having a high tensile strength, being wound closely round and in intimate contact with the shell. The fibre of the coil is at right angles to the circumferential stresses, avoiding the risks common to pipes with brazed or welded joints and to drawn pipes where the fibre of the metal, being parallel to the circumferential stresses, is in the least effective position for resistance. The steel coil is wound on the shell while it is rotating in a bath of molten alloy, the melting point of the alloy being sufficiently high to be unaffected by the temperature of steam of high pressure, and by this process shell and coil are fused into a solid mass.

In a recent issue of *L'Industrie*, M. Villon describes the use of liquid sulphurous acid, as practised in Germany, for the *purification of oils*. The oil to be purified is put in a cylindrical boiler of double sheet lead, furnished with a paddle agitator or any other improved device. There is introduced

into the oil, by a tube, ·05 to 1·00 per cent. of liquid anhydrous sulphurous acid, which is immediately vaporized and acts upon the albuminous and proteic coloring matters of the oils. To stimulate and complete the reaction, heat is supplied by steam in a worm pipe. This produces an increase of pressure, indicated by a manometer, but which ought not to exceed 13·7 pounds per square inch. The mixture is allowed to cool and the reaction prolonged several hours, after which it is washed a number of times with warm water and filtered. This process appears to give good results; the oil obtained is clear, slightly yellowish and very bright; it burns well without carbonising the wick, or acts as a lubricant without forming coom. The waste of this process is not great, and the oil retains its valuable qualities several months. Attempts have been made to combine the purification by chloride of zinc with that by sulphurous acid, and the results are more complete. When the chloride of zinc is used it is necessary to wash the oil well, for the presence of but a small quantity of this material, left in the oil, opposes combustion. The oil is first agitated with the chloride in solution as a syrup, and then the whole is treated with sulphurous acid, as has been explained.

ELECTRIC RAILWAYS IN THE UNITED STATES.

Mr. Joseph Wetzler, a well-known electrical engineer, in an interesting article on the growth of the electric railway system in the United States, contributed to a recent impression of *Scribner's Magazine*, is authority for the statement that there are at the present time 850 electric railways in the United States, operating more than 9,000 miles of track, with 2,300 cars, and representing a capital investment of $400,000,000.

An idea of the rapidity and magnitude of the extension of this system of traction may be formed when the fact is noted that, in 1887, the electric roads in the United States numbered only thirteen, with about 100 cars in operation.

MAGNETIC PROPERTIES OF IRON, NICKEL AND MAGNETITE AT DIFFERENT TEMPERATURES.

M. Curie, who has been investigating the magnetic properties of bodies at different temperatures, has published the results of his studies of iron, nickel and magnetite, in a recent impression of the *Journal de Physique*, an abstract of which, from London *Nature*, is given herewith. The important bearing of these researches upon the practical solution of the problem of the thermo-electric generator lends to them a special interest.

"The present paper deals with iron, nickel and magnetite. In the case of iron, measurements have been made at temperatures between 20° C. and 1,360° C., and for field strength of from 25 to 1,350 C.G.S. units. The observations on nickel and magnetite were only made at temperatures above that at which the great change in the magnetic properties of these bodies takes place. The values obtained with iron up to about 756° C. agree with those

previously obtained by Dr. Hopkinson. Above this temperature the author finds that the curves showing the relation between the intensity of magnetisation (I) and the strength of the field are straight lines passing through the origin for temperatures between 750° and 1,280° F. decreases more and more slowly. At first, (I) decreases to half its value for a rise of temperature of a few degrees, but between 950° and 1,280°, the susceptibility is almost a constant, only decreasing very little as the temperature rises. At a temperature of about 1,280°, the susceptibility suddenly increases by about 50 per cent., and then again gradually decreases up to 1,365°. The author, with some hesitation, gives the following explanation of this behavior: 'Up to a temperature of 860°, iron behaves like any other paramagnetic body. At a temperature of about 860°, however, it begins to change into a second allotropic form, this transformation being complete at about 920°, the iron remaining in this condition up to 1,280°, and behaving like such a body as oxygen or palladium. Finally, at 1,280°, the iron changes suddenly back to its first condition.' The attractiveness of the above theory can only be appreciated by a study of the author's curves, for if the curve showing the connection between the logarithm of the susceptibility and the logarithm of the temperature is plotted, it is found that the curve between 750° and 860° would, if prolonged, form, with the curve above 1,280°, a curve in all respects similar to the curves obtained in the case of nickel and magnetite. With nickel the author finds that the temperature of the magnetic transformation is about 340°. Above this temperature the susceptibility is independent of the strength of the field, and decreases regularly and very rapidly as the temperature rises. In the case of magnetite the chief magnetic transformation takes place at a temperature of 535°. At temperatures between 550° and 1,370° the susceptibility is independent of the strength of the field and decreases regularly, and between 850° and 1,360° varies inversely as the absolute temperature. The value of K (see previous note, *loc. cit.*) being given by the expression

$$K = \frac{0{\cdot}0280}{T}$$

where T is the absolute temperature. From the differences exhibited by the behavior, with change of temperature of diamagnetic and paramagnetic bodies, the author considers that these two properties must be attributed to different causes."

ELECTRICITY *vs.* STEAM ON RAILROADS.

Mr. Frank Sprague, an electrician whose opinions on the subject are entitled to the highest respect, contributes an interesting paper on the above subject to a recent impression of the *Engineering Magazine*. In the course of this the author expresses the belief that electricity will only in part take the place of the steam locomotive for railway service, and then only when the number of units operated between terminal points is so large that the resulting economy will pay a reasonable interest on the combined cost of a central station system of conductors and the motor equipment, and the traffic existing is commensurate with the needs of such a system. "Let us lay aside,

then," he says, "some of the visionary prophecies concerning electric railways. Perhaps no one has been more actively identified with them than myself; no one, I think, has greater faith in the future of the electric railway than I; but its future is not in the wholesale destruction of existing great systems; it is in the development of a field of its own, with recognized limitations, but of vast possibilities. It will fill that field to the practical exclusion of all other methods of transmitting energy; it will replace the locomotive on many suburban and branch lines; it will operate almost all street railway systems and elevated and underground roads; it will prove a valuable auxiliary to trunk systems; but it has not sounded the death-knell of the locomotive any more than the dynamo has sounded that of the stationary steam engine. Each has its own legitimate field, which will play its proper part in the needs of all civilization."

BOOK NOTICES.

Pray's Steam Tables and Engine Constants, for Facilitating all Calculations upon Indicator Diagrams, or Various Problems Connected with the Operation of the Steam Engine, from reliable data, with precision. By Thomas Pray, Jr., C.E. and M.E. New York: D. Van Nostrand Company. 1895.

Those engineers who have followed Mr. Pray in his methods of determining the power of steam engines by the indicator, will find this volume of tables a valuable continuation of his "Twenty Years with the Indicator." The eighty-five pages of tables contained in this volume and the accompanying forty-one pages of explanatory text, if as accurate as they seem to be in all respects, cannot fail to form a valuable assistant, particularly to young engineers who have not entirely familiarized themselves with all that has been written upon this subject.

The tables are so arranged as to be readily used, the first being the "Ratio of Expansion, Cut-off, etc.," with hyperbolic logarithm, capable of being read across the page for all computations; the first column gives Cut-off; second, Ratio of Expansion for Cut-off in Column 1; third, Hyperbolic Log. + 1 of ratio of expansion in Column 2; fourth, Vega's Log. of Column 3; fifth, Constant for Mean Exerted Pressure at Cut-off in Column 1; sixth, Vega's Logs., Column 5. In relation to this table, the text calls particular attention to the necessity of computing the total amount of clearance, and is clearly expressed, as also is the method of arriving at the gain from expansion.

The second table, pp. 23–36, gives the Heat Units in Water, 32° F. to 212° F., followed by Factors of Evaporation, the equivalent of (from and at 212° F.). In the text, this is followed by notes on the economy of feed water heating. Table No. 4, pp. 39–45, gives the Heat of Steam, the first column giving temperature of the steam in Fahrenheit degrees; column "H" gives

total heat of steam from 32° F.; "L," latent heat of vaporization from 32° F.; "P," pounds per square inch at 45° latitude, sea level, mercury at 32° F.; "h," heat of the liquid from 32° F. In this table, the points marked with (x) are the points of Regnault's observations converted into Fahrenheit degrees, which are claimed to be precise in every instance, and all computations are with the strictest regard to his own observations.

Pp. 46–52 give tables for each degree of Fahrenheit. Pp. 53–66, tables of Hyperbolical Logarithms to Five Places, Notes as to Clearance Included, as Changing Ratio of Expansion. Pp. 67–70, Engine Constants, which are computed entirely by the author, beginning with the diameter of the piston, the area, the logarithm of the area; the constant for one foot; the constant for 100 feet; the constant for 1,000 feet; the logarithm of 1,000 feet. This table is said to have been calculated with the best table of logarithms, and, is, so far as I have recalculated it, from personal observation, more accurate than similar tables in some books that have long been considered standard. Pp. 71–75 give tables of the Pressure, Volume and Density of Saturated Steam, with nine columns of useful data, and these are followed by Regnault's results at the Paris observatory (pp. 76–78).

Pp. 80–81 give Mean Pressure (absolute) Multipliers for any pressure in each one-thousandth of the stroke. Pp. 82–85, the last table of the book, give data from Rankine, computed by the author, of steam used expansively.

The author explains that after careful investigation he has decided upon following Regnault as the most reliable authority in tables for pressure, temperature, volume and density of dry saturated steam, holding to 26·36 cubic feet to the pound, in preference to 26·57, as given by Wood and other authorities.

Many of these tables will be found useful in reference to matters other than those connected directly with the steam engine, particularly the tables of weight of water in regard to its temperature.

The size of the volume, 10 inches by 6¼ inches, is handy, and the clearness of the type makes its use for reference convenient and agreeable. The margin of each table is sufficiently wide to permit the same kind of marginal index to be applied as that which has proved so convenient in Foley & Pray's "Engineers' Reference Book," which system might well have been added to this volume. C. S.

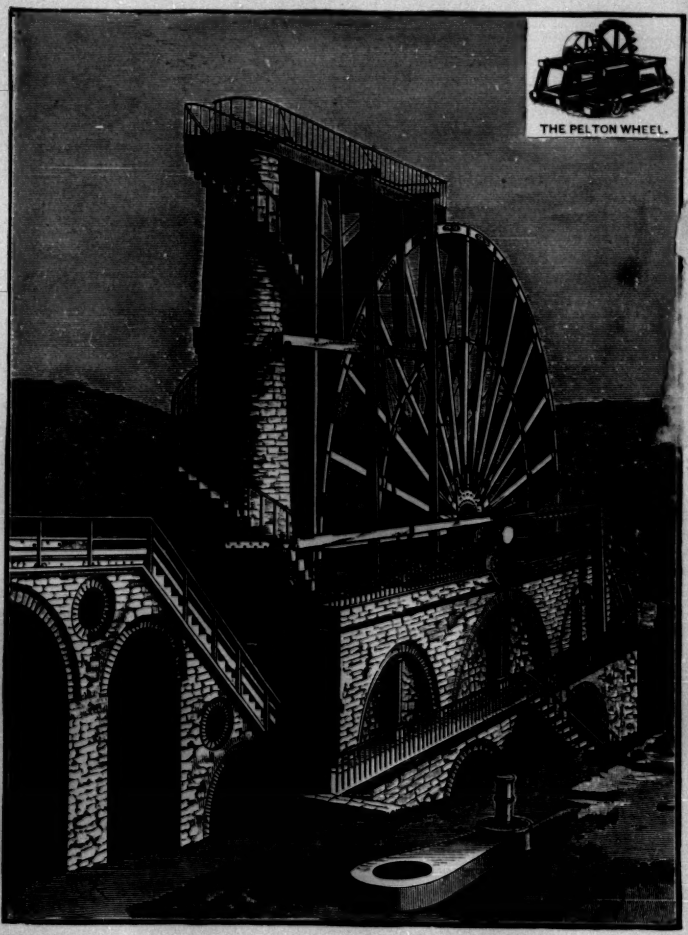


FIG. 6.—THE OVERSHOT WHEEL AT LAXEY, ISLE OF MAN.